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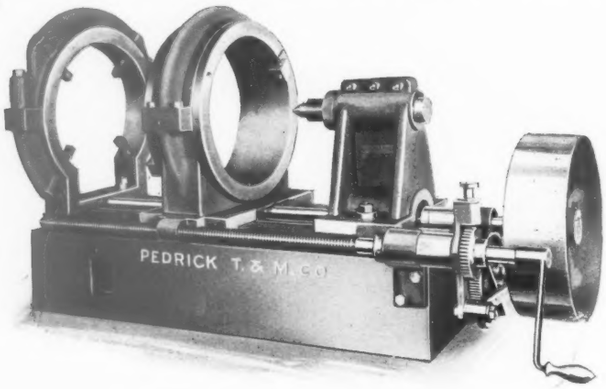

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Railway Mechanical Engineer

Volume 91 October, 1917 No. 10

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Location of Cab Appurtenances

Our American locomotives have been equipped with various labor saving devices to make the work of the engine crews easier and to increase the efficiency of the power, but little has been done, in a scientific way, to determine the proper location of the various cab appurtenances for the convenience of the men. We have known in a general way where the firedoor should be located on the back head of a locomotive boiler, but how high it should be above the cab deck was always a matter of individual opinion. In common practice, the door has been as low as 17 in. and as high as 25½ in., and until the motion picture studies made by the Pennsylvania it was anybody's guess as to which was correct. The tests made by this road, which are described elsewhere in this issue, show that a firedoor, the bottom of which is 22 in. above the cab deck, is the best average height regardless of the height of the firemen. At this height and with the coal always at the same point back from the door, a locomotive can be fired with the least muscular effort. This means more contented firemen and more efficient firing, as the fireman will not be wasting energy in the performance of his work. These tests also showed that with long fireboxes the coal can be better distributed with a grate slope of 2 in. to the foot. These and similar studies of the cab arrangement, which will result in a reduction of labor on the part of both the enginemen and firemen, will be reflected in the more efficient handling of the locomotive.

A Big Job Ahead

R. H. Aishton, president of the Chicago & Northwestern, gave some extremely interesting figures as to the growth of railway traffic in this country during the war in a paper before the St. Louis Railway Club last month. For instance, with only a small increase in the number of miles of line, locomotives and cars, the traffic for the calendar year 1917 promises to be 52 per cent greater than for that of the fiscal year ended June 30, 1915. This increase of 140,000,000,000 ton miles is equivalent to the total traffic moved annually before the war by the following 14 countries: Germany, France, Russia, Spain, Sweden, Switzerland, Roumania, Holland, Canada, South Africa, Mexico, Japan, Brazil and New South Wales. Stated in terms of tons, rather than ton miles, this increase would require 720,000 trains, containing 18,000,000 cars; this is equivalent to a train 136,363 miles in length.

The railroads are today unable to handle all of the traffic that is offered to them, and conditions will be worse as the winter comes on. The cars and locomotives are showing signs of the severe stress to which they have already been subjected. New equipment and additional facilities are not available. What can the mechanical department do? In the first place, cooperate more closely with the operating department. Utilize every possible pound of tractive effort, or at least get the operating department to do so. The charge has been made that the mechanical department, where it has had charge of rating the locomotives, has shown a tend-

ency to rate them too low. Train load figures on some roads would seem to substantiate this claim.

There is a tendency on the part of some mechanical department officers to pass the buck, or excuse themselves because they say they are working under impossible conditions and cannot do better under the present conditions of labor and material. The world today in every field of endeavor is doing things that only a year or two ago seemed impossible. The railways of this country must not and cannot fail, difficult and impossible as the conditions may seem. If every man in the mechanical department will really get busy and exert himself to the utmost, the problem can be solved. The difficulty is, of course, to push through a sufficiently patriotic educational campaign to do this—and yet it must be done.

Locomotive Terminal Competition

Remember that the competition on how to decrease the time a locomotive is held at a terminal which was announced in last month's issue, page 474, will close October 22. There are only a few days left in which to write your story and get it to our New York office. We have named that peculiar date as we realize the necessity of publishing the articles received before winter begins. Tell us what you are doing to put the locomotives under your charge through the roundhouse with the least possible delay. In a large number of cases a locomotive spends more than one-half its time in the roundhouse or its immediate vicinity. This is too much under present conditions with the power in such great demand. We want to tell others how you have decreased your terminal delay. A prize of $35 is offered for the best paper, $25 for the second best, and $15 for the third; all other contributions accepted for publication will be paid for at our regular space rates.

Second Call for the Liberty Loan

"Shall we be more tender with our dollars than with the lives of our sons?" is a slogan appearing on some of the posters calling for subscribers to the second second Liberty Loan. It is particularly fitting in the case of railway men, many of whom have given their sons or comrades to the service of the Allies in France. The least we can do at home is to help our Government provide these men with the necessary facilities to complete the big task before them. Moreover, the Government will pay as much and more in interest than many savings banks. The first Liberty Loan was a great success, being oversubscribed by 50 per cent. We can show our enemies no better example of our unity and determination to win the war than by giving financial aid to our Government. A large number of railway men supported the first loan; in the Colonie (N. Y.) shops of the Delaware & Hudson, the main shops of that road, 73 per cent of the employees subscribed. Start a campaign on your own road and see if you can beat this record.

The Railroad Y. M. C. A.

This issue of the *Railway Mechanical Engineer* will reach its readers while the movement of the selected men to the National Army cantonments is still in progress. One of the organizations that will take a big part in the work of carrying these men will be the Railroad Y. M. C. A., which, by placing its secretaries on these trains will complete a Y. M. C. A. chain from "Home to Home." Despite its short notice the Railroad Y. M. C. A. succeeded in accompanying about 300 trains of the second contingent of 40 per cent. Its secretaries explained to the men the work that the Y. M. C. A. is preparing to do at the cantonments and told them how the Y. M. C. A. would accompany them on their way to the cantonments, from the cantonments to their transports, at the piers, in London or in Paris where it has big hotels for the use of men on furlough, in camp in France, even in the front line trenches, and thence back once more to home. They also distributed post cards and stationery and in other ways, by personal contact especially, made the trip easier for the men themselves, for those in charge and for the train crews. But this is not all that the Railroad Y. M. C. A. is doing; it is meeting troop trains at division points; it is opening its buildings to the men in olive drab and it is meeting them at the embarkation piers to bid them "bon voyage." It also has men in France with the railway engineer regiments. In short, it is missing no opportunities to do its utmost for the soldiers.

Utilizing the Boiler Capacity of Locomotives

Many freight locomotives now operating on the railroads of this country have considerable potential tractive effort which is not being utilized. There are some cases where changes in the proportions of locomotives would make them much more efficient transportation units.

Before the superheater was generally adopted many locomotives were built with the boiler capacity too low for the cylinders, which resulted in steam failures and poor performance generally. The proportion of the heating surface to the cylinder volume was increased and much better performance was secured. At the present time it seems that this tendency has been carried too far in the case of many freight locomotives. Eight or ten years ago, it was by no means unusual to find locomotives designed with only 200 sq. ft of heating surface for each cubic foot of cylinder volume. At the present time this ratio is more often above 250 and sometimes greater than 300. In passenger locomotives this is no doubt good design, but there is little advantage in having a freight locomotive that can supply steam at long cut off at a speed above 20 miles an hour. It is the tractive effort at low speed and not the proportion of the boiler capacity to the size of the cylinders that determines what a freight locomotive can haul over the division.

There is of course a practical limit to the tractive effort which can be developed, determined by the adhesion between the wheel and the rail. If the full adhesion is utilized the locomotive will have a tendency to slip and will be hard to handle. Just where the practical limit is reached is hard to determine. The coefficient of friction between the wheel and the rail is usually considered to be about 25 per cent, which would call for a factor of adhesion of four. The value of the coefficient of friction generally used is probably lower than the actual value. Some roads have brought the ratio of adhesive weight to tractive effort down to 3.5 and 3.8 is by no means uncommon. It would seem that a locomotive with a factor of adhesion of four should not give trouble by slipping even after the drivers have been turned and the cylinders bored.

Where freight locomotives have ample boiler capacity to supply the cylinders and the factor of adhesion is greater than four the logical thing to do is to increase the size of the cylinders to make the tractive effort full 25 per cent of the weight on drivers, providing, of course, that the machinery is capable of standing the increased stresses which will result. It is hardly probable that the steam consumption will be unfavorably affected by the larger cylinders, and the hauling capacity will be increased.

When locomotives are modernized the factor of adhesion and the ratio of heating surface to cylinder volume should be carefully considered. Superheaters and brick arches are usually applied to save coal, the increased speed which it is possible to secure being considered an incidental advantage.

There seems no reason why the increased boiler capacity should not be utilized by making a corresponding increase in the tractive effort, due consideration being given, of course, to the strength of the machinery and the ratio of adhesion. On one road a superheater was applied to a large freight locomotive and it was found possible to increase the diameter of the cylinders 1½ in. without overtaxing the boiler. It might be argued that the heating surface of a boiler does not always give a true indication of its evaporative capacity and it is difficult to forecast accurately the actual boiler performance, but in view of the fact that the cylinders can easily be bushed in case they are too large, it would certainly be best when changing cylinders, to make them large enough to develop the full adhesion of the driving wheels.

At this time, when the railroads are so hard pressed for motive power, any method of increasing the tonnage that can be hauled is of great importance. A careful consideration of the proportions of existing locomotives will in some cases, reveal sources of increased tractive effort that have not been considered.

The Abuse of Compressed Air

The introduction of tools driven by compressed air marked one of the greatest advances in railroad shop practice and such equipment is now almost indispensable. Compressed air is naturally adapted to use in railroad shops. The tools are made in such forms that they can be used in almost any location and they give little trouble if they receive a moderate amount of care and attention. Compressed air can be more readily applied to driving small tools than any other form of power. When a new device which must be independently driven is designed in a railroad shop the first thought is to fit it with an air cylinder to operate it. For tools that are used only a small portion of the time this is no doubt the most economical method of driving, but for those that are in operation continuously either belt or individual motor drive is usually to be preferred, as the decreased power consumption resulting from these methods of driving as a rule offsets the greater first cost as compared with pneumatic drive. Compressed air is in nearly every case the most expensive form in which power can be used, as few railroad plants are equipped with efficient types of compressors.

An interesting example of the extravagant use of compressed air in shop tools is furnished by a shear which was seen in operation recently at a large scrap dock. The whole device had been made from second-hand or scrap material, but while it testified to the ingenuity of the man who designed it, it could not be called an economical machine. The shear lever was operated by a 14-in. by 12-in. air cylinder which made a full stroke for each operation. The air was supplied from a line carrying a pressure of 100 lb. per sq. in. The machine was operated almost continuously and made an average of five strokes per minute. Thus it required 5.34 cu. ft. of compressed air, or 41.6 cu. ft. of free air, per minute, if full pressure was secured for only half of each stroke, a very conservative estimate of the air consumption. At a rate of two cents per 1,000 cu. ft. of free air the cost of power for this machine was 48 cents a day. The cost for such a machine if driven electrically should not have been more than one-fourth of that amount. The expense of installation of wiring would have been less than for piping and the reduced cost of operation would certainly have justified the greater initial expenditure for motor drive.

Air motors made in railroad shops are practically without exception extravagant in the use of air, usually due to the poor design of the apparatus. Pneumatic tools which give a fair output of power for the air consumed require a degree of precision in their manufacture that cannot be attained with the machine tool equipment found in railroad shops.

A feature of compressed air installations that should be kept in mind is the possibility of large losses due to leakage. While, of course, in some pipe lines the losses are very slight, there are almost always small leaks in shop lines which are considered of no importance and are not stopped. The condition of connections is seldom given the attention it requires and much air is wasted at the fittings. With the high pressure carried, the loss due to even a small leak is quite considerable. At a pressure of 100 lb. per sq. in. a hole only 1/16 in. in diameter will allow the escape of 387 cu. ft. of free air per hour. Assuming the cost of compressing air to be two cents per 1,000 cu. ft., a single hole of that size will waste power at the rate of $5.50 per month. As a rule, there are numerous small leaks in every line of pipe, though often they are not apparent. At one shop where a leakage test of air piping was conducted it was found that the power lost in that way cost more than $2,000 a year.

These observations should not be construed as reflecting unfavorably on compressed air as a power medium in shops. The intention is rather to show the waste that may occur in the system unless it is properly maintained and to emphasize the necessity for carefully considering all the elements entering into the cost of production to insure economy in shop operation.

Freight Car Repair Situation

How to get freight cars repaired is unquestionably one of the most serious problems confronting the mechanical department at the present time. With railroad operation speeded up as it is now, cars are certain to require more than the ordinary amount of repairs to keep them in good condition. There is plenty of evidence to show that the roads are getting more service from their cars than ever before. The achievement of the railroads in increasing the tonnage handled since this country entered the war has been remarkable. Cars must be kept in repair in order that this splendid record may be maintained.

During the past four months both the mileage and the tonnage per car have broken all previous records. During the period from 1913 to 1915, freight cars moved on an average from 26 to 28 miles a day. In 1916, this had increased to 31.5 miles and the figures for 1917 will be considerably higher as the latest available statistics show that the railroads in June handled 23 per cent more traffic than in 1916 with only 3 per cent more cars. At the same time the average carload and the average trainload have also increased.

There can be but one result; that cars require more repairs than under normal operation. New cars are not being received by the railroads in any considerable numbers, but the demand for equipment has been met by putting in service many cars that were formerly marked for retirement. Only a small proportion of these have been reinforced. The others will demand an abnormally large amount of repair work to keep them in service. Many roads have only sufficient facilities to take care of car repair work under normal conditions and to keep cars in serviceable condition during the war will necessitate a great increase in the output of the car shops.

The roads have made a good record in reducing the number of bad order cars during the past year. On June 1, 1916, 6.8 per cent of the freight cars of the country were in shop or waiting to be shopped, while on May 1, 1917, the percentage was 5.7. On June 1, however, the figure had risen again to 5.8. It should be noted that the decrease in the total number of bad order cars during the period from June 1, 1916, to June 1, 1917, was due to a reduction in the

number of home bad order cars, as the number of foreign bad orders increased 18 per cent during that period. This fact seems one of great significance. It shows that there is a tendency to neglect the repairs to foreign equipment. In some cases foreign cars are held for long periods awaiting repairs in spite of the heavy per diem charge. More often, however, just enough work is done on the foreign car to get it safely onto the line of some connecting road and after it has made a few hundred miles it is again ready for the repair track. The present rules permitting the loading of cars in any direction to handle the traffic keeps a great many cars off the home road for long periods and the condition of the cars suffers. As one chief interchange inspector remarked, "Everybody is ready to use the foreign cars, but nobody wants to repair them."

The shortage of cars, combined with the new car service rules, has created conditions which add to the importance and also to the difficulties of the car inspector's work. A broad construction of the M. C. B. rules is essential if they are to give the best result under the present circumstances. Cars must proceed with the least possible delay to avoid shortage of equipment and congestion of terminals. Of course, nothing should be done which would in any way jeopardize safety, but at this time inspectors are not justified in holding up cars for minor defects. To make out defect cards and collect the bills often costs more than the company receives for the repairs which it makes on the authority of the cards.

Car inspectors should not lose sight of the fact that the earning power of freight cars is greater now than ever before. Delays to cars cause delays to trains, with resulting expense due to the loss of time of train crews and locomotives. The amount that may be wasted through minor delays can be realized from the fact that a conservative estimate of the earning power of a freight locomotive at the present time is $100 a day.

Cards should be issued for defects which demand repair, but the practice of carding for minor defects is a waste of time. It is not uncommon to find defect cards which have remained on cars so long that they have become illegible. The car may have run for months with the defect for which it was carded, there being no necessity for making repairs. This is often the case with such insignificant damage as raked siding, roofing raked on the end, metal posts slightly bent, etc. To issue cards for such defects is a foolish policy.

While cards should not be issued unless it is necessary, they should be applied when the conditions are such that the receiving line is entitled to protection. The practice of running cars on records should be done away with entirely. Some roads make a practice of tracing for defect cards on the assumption that cars have been run on records. It is doubtful whether the returns from this practice were ever sufficient to justify the expense. The sooner it is given up the better it will be for all concerned.

The changes made in the M. C. B. rules during the last year have been very few, and all inspectors should be thoroughly familiar with the present code. Some important changes have been made, however, in the loading rules and inspectors should study the revised rules and do everything in their power to see that shippers adhere to the proper methods of loading. Numerous delays result from improper methods of securing lading. If inspectors would make it a practice to report all cases of improper loading in order that the matter might be taken up with the shippers, conditions could be very much improved.

The new specifications for tank cars contain considerable material with which inspectors should be familiar in order to insure safety in the transporting of dangerous liquids. Of equal or greater importance are the regulations covering the handling of explosives. Large shipments of such material will be made during the war, and the booklet of instructions issued by the Bureau of Explosives should be in the hands of every inspector.

The demand for cars is so great at this time that shippers will load cars almost regardless of their condition. If defects are discovered after cars are under load, the repairs are often more difficult to make or the load must be transferred. Inspectors can do a great deal of good if they will exercise their ingenuity to catch defects before cars are loaded.

Unfortunately, at the present time, it is not possible to route cars to points where it is certain that they will receive adequate repairs. Many eastern roads are now shipping westward freight which requires only rough freight cars. Unless some special effort is made to get these cars to shop points, they will not be in condition to handle grain and flour when they reach the western roads. Since these commodities often originate at points which are not provided with repair facilities, there is danger of cars being loaded which are not in condition to be used for such products. No dependence can be placed on car inspection by agents or elevator men, and if leakage is to be prevented, cars must be thoroughly inspected and repaired before they are sent out to be loaded. There is probably not an interchange point that does not have cases where cars are set back and transferred and sent back to some point on the delivering line without repairs being made. Soon the same car appears at another point under load and is either rejected with consequent loss, due to transferring the load, or it is moved on to make trouble on another line.

The condition of equipment is causing serious situations at some points where large numbers of cars are interchanged. Unfortunately, the large interchange points are not always shop points. Equipment cannot be handled readily if it arrives in bad order and long delays result. It has been suggested that shops operated jointly by several railroads would be a help in improving the conditions at large interchange centers. In some cases these facilities are badly needed by all the roads, yet the individual roads do not feel justified in going to the expense of putting up shops. The prices paid for repairs under the M. C. B. rules are not high enough at the present time to make such shops profitable.

Attention has already been called to the danger that lies in the practice of slighting the repairs to foreign cars and cars requiring complete overhauling in order to reduce the number of bad order cars. Nevertheless, there are many repair tracks that are following just such a policy. At one typical repair point, which was visited recently, a considerable number of foreign bad order cars were being repaired. While many required heavy repairs, only such work as was necessary to put them in a safe condition was being done. For example, one box car had been brought to the repair track because the draft timbers had been pulled out and one sill broken. About 25 per cent of the lining in the car was missing and the decking was broken. The repairs to the draft rigging were made, but the work required on the body of the car was not done. When it left the repair track, the car was fit for nothing but rough freight, and it was probably taken out of service again in a short time for body repairs. The foreman in charge of the work at this point volunteered the information that repairs to foreign cars were a losing proposition, since the price of materials had advanced so greatly. He had more work on system cars than he could take care of, and he couldn't bother much with foreign repairs.

The attitude of this car foreman is one too commonly found among the shop men. In their anxiety to save money for their company, they overlook the ultimate gain to be secured by furnishing serviceable cars to the road. Though

the prices of iron and steel products have been reduced, the increase in the cost of many other materials entering into the construction of cars has, of course, been much greater than the increase in the M. C. B. prices. There are several circumstances that should be considered in this connection, however.

In practically every case where material is applied to cars, scrap material is also removed. The price of scrap has advanced, so the increase in the net cost of the material applied is not so great as the increase in the price of new materials. Then, too, large stocks of materials were contracted for at prices lower than those prevailing at the present time, thus bringing down the average cost of the material. The present schedule of prices was adopted only after a careful consideration, and no man should slight the repairs to foreign cars because he fancies his road will be the loser. If every road gave the same attention to foreign cars that it gives to system cars, the debits and credits would be quite evenly balanced. Unless repairs are made as soon as defects appear and the work done in a thorough manner, cars cannot be kept in condition.

No one can deny that the car foremen have a hard task at this time. The shortage of materials is hampering the work on many roads, and the labor shortage is still more serious. The wages paid are lower than in the motive power department as a rule, and it is difficult to keep workmen. Much more time must be devoted to the supervision of inexperienced men who are being employed. The temptation to get the cars off the repair track regardless of whether they have been properly repaired or not is very strong. Such practices, if followed, will cause serious conditions this winter, when the traffic will probably be even heavier than it is now. What is needed is good, honest, thorough repairing that will put cars in condition to give service, repairing that will not only get the car off the repair track, but keep it off.

Locomotive Repair Situation

An officer in the mechanical department when asked what his road was doing to prepare its power for the oncoming winter replied—"We are giving it a 'lick and a promise,' the same as every one else"—and went on to explain that at the present time the demand for power was so great that it could not be spared long enough from service to be given the full repairs needed. We fear that this method of handling the power is too common throughout the country and we question greatly the judgment of those who follow this policy. It is true that the demands for power were never greater than they are today and it is likewise true that the demands later in the winter will be still greater.

It is a great temptation for a railroad to use all of its facilities to the limit when revenue freight is begging to be hauled. But it is a short sighted policy to do so when by so doing the facilities are deteriorating to such an extent that later, their capacity, when even more traffic will be offered, will be much decreased. At present it is not only good business to use these facilities with a thought of the future but it is the duty of every railroad officer to see that these facilities are not so crippled as to interfere with the demands next winter. The mechanical department officers are responsible for the power and equipment. It is their duty to see that their roads are properly protected. If too great a demand is made of the equipment under their charge they should not be afraid to refuse to supply it when they know that by so doing they are courting sure failure later on. It is better to place one embargo now than two later when it might mean disaster to the country. Make the equipment work to the limit. Do everything that is possible to increase its capacity to do more work. But don't kill it.

High Points in Engine Maintenance

"Power and still more power," is the crying need of American railways today. There are two items in locomotive maintenance that are fundamental in answering this appeal. They are good steaming qualities and efficient steam distribution. They are of prime importance and mean more tonnage hauled and the efficient use of fuel. The engine house forces should concentrate on these items. Keep the flues clean; see that the superheater is fulfilling its duty; stop the leaking tubes; maintain the front end in proper condition; be sure the brick arch is intact; keep the boiler clean and as free from scale as possible; do not neglect the washing of boilers; see that the grate and ash pan are such that sufficient air will be admitted to the firebox properly to consume the coal. There is nothing more discouraging to the engine crew than a poor steaming locomotive; it is as demoralizing as was the "fluke" in the Giants' pitching staff to the entire team in the second game of the World's Series. Don't try to offset any of these defects by decreasing the nozzle—this means high back pressure and loss of power. Seek out the real difficulty and correct it.

The importance of square valves is thoroughly realized by every intelligent railroad man. The danger is in procrastinating and "letting it go for this time." Our armies in the field never go into action without everything being thoroughly prepared. Carelessness and procrastination there mean loss of life and perhaps defeat. We likewise must go into action with our equipment adjusted to do its full work. Efficiency at home is as vital as efficiency at the front. We must move every possible pound of freight that we can.

NEW BOOKS

Air Brake Association Proceedings. Edited by F. M. Nellis, secretary. 270 pages, 6¼ in. by 8½ in., illustrated, bound in cloth. Published by the association, 165 Broadway, New York.

This volume is the official report of the twenty-fourth annual convention of the Air Brake Association which was held at Memphis, Tenn., May 1 to 4, 1917. It contains papers on the Slack Action in Long Passenger Trains, Its Relation to Triple Valves of Different Types and Consequent Results in the Handling of Passenger Trains; Inspection of Brake and Signal Equipment; What is the Safe Life of an Air Brake Hose; Handling Heavy Tonnage Trains on Grades with Air Brakes Exclusively; the Functional Interrelation Between the Component Parts of the Air Brake System; Slack Action in Long Passenger Trains; Suggested Practice for the Cleaning and Lubricating of Brake Cylinder Packing Leathers, and revisions of the recommended practices. In addition to the papers, the discussion is given in detail. The Proceedings this year are prettily arranged typographically with the picture of the author of the paper and chairman of the committee accompanying each paper.

First Aid Instructions for Miners. By a committee of surgeons for the U. S. Bureau of Mines. 154 pages, illustrated, 5¾ in. by 4¼ in. Published by the Superintendent of Documents, Government Printing Office, Washington, D. C. Price, paper bound, 20 cents; stiff cover of red buckram, 35 cents.

This book, while prepared essentially for the instruction of miners, contains information that is of value to all who may be required to apply the first aid remedies to injured persons. It covers the subject quite thoroughly and includes an outline of an organization and the necessary equipment to be carried for the work, in addition to instructions regarding the handling of the patient. General information is given regarding the anatomy of the human body for the purpose of informing the first aid student so that he may better apply the principles outlined in the book. Instructions for action for all causes of accidents such as electric shocks, drowning, suffocation, cuts, etc., are included in the book, with plenty of illustrations to better describe the text. The pamphlet is perhaps the most complete treatise on this work that is included in the space given the subject.

COMMUNICATIONS

T. W. TOO SHARP FOR MM

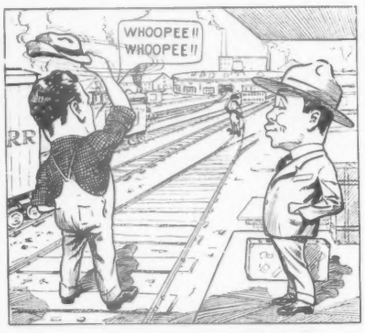
(With Apologies to Wallace Irwin.)

Chicago, Ill.

Honorable Editor:

I have undergo peculiar experience recent which I assume to recite for benefit all crafty mms who plot downfall other U. S. Federal I. C. C. detectors.

At small shop in north of state, I are much worry alway by failure to find clear case on which to issue Form 5 invitation. Mm are one of hale fellows who create good cheer at Atlantic City where convention are congregate. Chief Detector have interrogate me frequent about what fine shop and fine equipment mm seem to attain and praise record of same railroad profuse. Last time I alight, I are all alert with suspicion assuming kultur and spy all sides. First thing happen are switch man who always greet me with cordial relation step out to roundhouse running track and emit "whoopee, whoopee" to yard switchman ¼ mile away. This hand repeat exact antic and wave hat twice in circle around head also whoopee. I ponder now how this always repeat. I inquire to know this eulogy and switchman stutter and cough out that reason are weather report. I are curious to know what weather are like and he say storm are approach. It require about 15 minutes to consume distance to shop by foot and when I arrive I meet mm and foreman on ashpit. I remember now this also are same proceeding. Honorable mm are exceeding pleasant telling joke and bestowing cigar on entire crowd.



"First Thing Happen Are Switchman Who * * * Emit 'Whoopee, Whoopee' to Yard Switchman ¼ Mile Away."

I immediate see engine 1821 on pit with sharp driving wheel flange, deep wore tire, steam leaks and other defect. I volunteer that locomotive are in bad shape but mm laugh and say yes she going on drop-pit. I reply when and he report tonight when 1827 come off and point to shop card tack on pilot. I discover yard engine 1840 with brake pull-rod just escape rail, broken flange on inside pair tank wheel, tank leaking all points, lost sand pipe and two broken springs. I raise question this engine and mm reply she are mark for back shop. "Why do she have steam on?" I retort quick. He assume that this allow her to spot herself in shop so not to require shifter. I see 1836 on outbound track with valve stems blowing, bad leak at check valve and front cylinder cock gone. Foreman say he are holding engine now waiting for mechanic to repair. I see other engines but alway chalk mark are on pilot or man just starting to make repair. This are time I commence to smell mouse in woodpile and pass resolution in mind to call investigation. Things look like plot on U. S. government and I propose secret service. When I retire to station, mm smile broad, shake hand profuse and insist on two cigars with handsome gold wrapper. I arrive on train with nervous twitch in stomach and regret over being bunco. This are Friday night. Before sleep same night, broad smile same as mm also illumine visage poor Jap detector.

Monday morning see me same town but unload on opposite side station, climb freight train and speed to shop without whoopee or periscope show. I visit drop-pit and see No. 1827 have remove but 1825 on not 1821. I go out in yard and find engine 1840 working successful with brake rod down, bust flange, seepy tank and broke spring just same like before. I issue Form 5 invitation to engineer who grin with benign love on me and order him to shop. When I reach pit, I are confront with No. 1821 just arrive with sharp flange, deep groove on tire and steam escape like Friday. I make out invitation on him also. Two more engines which I see Friday, I discover now same way only no shop card paste anywhere. By now mm and foreman emerge excited and with usual smile smother approach with brake off. Hon. MM remark what unexpect pleasure have arrive with me and I retort pleasure all to me when I deliver 4 invitation from U. S. government.

I remark quiet, "Understand your wireless system shorted herself in storm Friday night." He turn quick on about face and emit something about hyphenate and yellow peril which are not appreciate by me, but I assume it are new joke and laugh with quiet uproar. With extreme satisfy to inside conscience I remark solo voice, "whoopee," same as switch hand.

Yours truly,

Tobesura Weno.

UNNECESSARY TRANSFER OF LOADS

Denver, Colo.

To the Editor:

The loads of approximately 25,000 cars are transferred during each month throughout the United States to facilitate the repairing of defective cars. There is no doubt but that about half of these cars could be run safely to their destination with their defects and unloaded. As the matter now stands the receiving line is the judge as to whether or not the lading in the cars is to be unloaded, and inasmuch as the cost of transferring and the payment of the damage claim is made by the delivering line, it is of course natural for the receiving line to transfer the load whenever there is the slightest difficulty in making repairs, delays to the equipment being entirely overlooked.

We may figure that a car is held out of service about five or six days when its load is transferred, a great deal of the time being lost in switching the car to and from the repair track. This means that the railways lose the service of the car for six days. It would be a good plan, owing to the scarcity of equipment at the present time, for the railways to agree to haul the cars which are received in bad order and which could be handled safely to their destination, at the rear of the train. There is no question but that the car shortage would be reduced by about 12,000 cars a month if this practice were followed. This number of cars would take care of a great many shipments. Instances have been found where loaded cars have traveled 1,000 miles in bad order, which upon arrival at an interchange point, about 40 or 50 miles from their destination, were held by the receiving line, request being made for authority to transfer the load so the receiving line would not be obliged to make the repairs.

It would appear that while cars are so badly needed on all lines, that the railroads should get together on this proposition and agree to run such equipment as is reasonably safe to handle. It would not only help the receiving line, but also the delivering line. Furthermore, it would save the receiving line the labor of transferring a great many loads, and labor at the present time is about as scarce as the equipment.

William Hansen,
Chief Joint Inspector.

WAKE UP! MECHANICAL DEPARTMENT

The Time Has Come When American Railroads Must Recognize the Importance of This Department

THE Interstate Commerce Commission statistics for the year ending June 30, 1916, show that the maintenance of equipment expenses for all of the railroads of the United States amounted to $570,326,407, or 25 per cent of the total operating expenses. When we remember that in addition to this direct expense for the maintenance of equipment the mechanical department requires the use of a large number of buildings and structures which are maintained by the engineering department; that a poorly designed or maintained locomotive can add greatly to the cost of maintenance of way; that one of the largest items of transportation expense is the fuel burned in the locomotives; and that the condition of the equipment and design of power affects the operating expenses in many different ways, the relative importance of the mechanical department is at once apparent.

In general, it is probably well within reasonable limits to estimate that one-half of the capital investment of an average road is in the cars and locomotives and in the equipment which is necessary to maintain them. A tremendous responsibility, therefore, rests upon the mechanical department and its head. American railroads for some reason or other do not seem to have an adequate appreciation of this fact. and as yet only one railroad on the continent—the Grand Trunk—has seen fit to dignify the office of the head of that department with an executive title.

Unfortunately, conditions as they have existed in the mechanical departments on many American railroads have not been such as to hold many officers who have been remarkably well fitted for the work. Other industries and even railway supply companies which manufacture only one or at most a few specialties which are required on a railroad, have been willing to pay salaries more commensurate with the ability of the men and have thus attracted a great number of them from the railroads.

Higher executive officers with little or no technical ability or knowledge have often interfered or dictated against the better judgment of the expert in charge of the mechanical department. Bankers and financiers have made it necessary to break down organizations when business has temporarily fallen off, when they should have been hard at work getting the equipment in shape for busier times. When business did improve organizations were hurriedly gotten together and the work rushed through with a lamentable lack of efficiency. Many motive power officers have found their positions almost unbearable and impossible because of this and because of interference from above in the handling of labor. Then, too, there has often been a lack of co-operation between the various departments in the purchase of material or equipment, the advice of the mechanical department frequently being disregarded. These "cheapest in first cost," "lightest in weight" and "personal preference" purchase policies must absolutely be done away with and the recommendations of the mechanical department, based upon careful and critical analysis and technical study, must be recognized. Mechanical department officers may be criticised for lack of initiative in standardization of equipment, in the better organization of their forces, or for failure in developing the most efficient designs, and for many other things, but if the responsibility is put squarely up to them there is little doubt they will make good.

Conditions as to supervision in many mechanical departments are to-day in a most deplorable condition. In the first place, there is a minimum of supervision. In the next place, a large percentage of the minor officers are working longer hours and getting less salary than the day worker is receiving for his work. Many minor officers have gone back into the ranks as mechanics, thus being relieved of much responsibility without financial loss. Is it reasonable to expect that ambitious men will seek for promotion from the ranks under these circumstances? Where are the officers to be trained and developed for higher positions if this condition is allowed to continue?

On what basis should a mechanical superintendent or any other mechanical department officer approach his task?

How can such an officer be of the greatest possible value to his company? What possibilities are there for advancement if he makes good?

These are vital questions to any mechanical department officer. Indeed, his value to his railroad, to railroads in general, and to the prosperity of the country at large, depend entirely on how he answers them. Not a few mechanical department officers take a narrow view of their duty and responsibilities. They seem to measure or gage their success in terms which fail to comprehend in a big way the problem on which they are engaged—terms which have no vital relation to the efficient operation of the road as a whole. They forget that the real business of a railroad is transportation, and do not realize that their chief object should be to serve and be useful to the operating department. They forget also that they should act as business men and operate the mechanical department on strictly business principles with a view to successful operation.

In some cases there may be a shadow of an excuse because of the narrow conception of the real function of the railroad on the part of their superiors. The bankers who control the properties are, in the last analysis, often to blame. Conditions are changing rapidly, however, and it is up to the mechanical department officer to grasp the full significance of his opportunity and get his house in order. That greater recognition is being given to mechanical department officers is indicated by recent promotions and appointments.

As was noted in the September number of the *Railway Mechanical Engineer*, page 475, W. D. Robb, of the Grand Trunk, has the honor of being the first vice-president in charge of motive power, cars and machinery on the American continent. Why was Mr. Robb thus honored? What qualifications does he possess which specially fit him for his new position? The organization on the Grand Trunk has been somewhat different from that of other roads in the United States and Canada. Mr. Robb, as superintendent of motive power, did not have authority over the car department, but in its place had full responsibility for the engineers and firemen. It is significant that he has had splendid success in handling the labor problem. He is positive, a capable organizer, thorough and careful in his methods, and has kept his power in first-class condition. He will not stand for "paint shop repairs," and his subordinates understand this clearly and fully. Equipment builders have had reason to feel it also, because of Mr. Robb's insistence upon standards of design and workmanship.

That Mr. Robb is equipped with that degree of vision and foresight which is so essential for a successful executive officer is indicated by the persistent way in which he has developed modern apprenticeship methods. Except for a few glaring exceptions, other roads have failed to give this subject the attention it deserves, although the railway press, and men like Basford, Purcell, Cross, Thomas and Russell have persistently, forcefully and intelligently pounded it home. Mr. Robb has undoubtedly felt that he has been many times repaid for his efforts in this direction in the returns which he has received in the past three years alone. A real vision, an active imagination and the backing of the management have been factors in his success in this work.

If Mr. Robb's administration of motive power affairs has been weak in any respect, it is because of the lack of contributions from the Grand Trunk to improved features of locomotive design; on the other hand, Mr. Robb has not been slow in taking advantage of those things which have been developed on other roads, and have been found to be successful. He has steered clear of fads.

Another appointment which was announced in the September number of the *Railway Mechanical Engineer* which holds a certain amount of promise to the mechanical department was the promotion of George W. Wildin from general mechanical superintendent to general manager of the New York, New Haven & Hartford. Mr. Wildin, of course, leaves the mechanical department, and in this respect his promotion has a very different significance from that of Mr. Robb. It is reasonable to suppose, however, that it will result in a greater appreciation of the mechanical department on the part of the management, for few men have had so varied experiences in that department as Mr. Wildin, or have more reason for appreciating the necessity of giving the department a fair chance and a square deal.

Mr. Wildin is a big, broad gage, forceful, outspoken chap. He is orderly and systematic and a good handler of labor. He is a resourceful and ingenious designer, and knows the mechanical department from start to finish, for he has held about every different kind of job that that department can offer, and his experience has not been confined to any one section of the country.

The promotion of D. F. Crawford early in the year from general superintendent of motive power to general manager of the Pennsylvania Lines West, will also be remembered. It serves to emphasize the possibilities for promotion for mechanical department officers, and recalls also the deeply grounded understanding on the Pennsylvania that the chief function of the mechanical department is to serve the operating department to the best of its ability.

Mechanical department men have viewed with delight the steady climb upward of W. W. Atterbury to the vice-presidency of the Pennsylvania, presidency of the American Railway Association and to his recent appointment as brigadier-general in charge of railway affairs in France under General Pershing. Mr. Atterbury started in as an apprentice in the Pennsylvania shops at Altoona, and in 1903 was promoted from general superintendent motive power to general manager, becoming a vice-president in 1909.

H. C. Oviatt, who was appointed general superintendent of the New Haven at New Haven last spring, began as a locomotive fireman on that road, and rose to the position of assistant mechanical superintendent before being transferred to the operating department. He has just left the New Haven to take an important position in charge of transportation for the American International Corporation, division of ship building, at Philadelphia.

John Purcell, in charge of mechanical department affairs on the Santa Fe, has the title of assistant to the vice-president, which is well deserved, and we hope will some day be shortened by three words. H. H. Vaughan had this same title before he left the Canadian Pacific to engage in the munitions business. J. Hainen, in charge of the mechanical department on the Southern Railway, is also designated as assistant to the vice-president.

Among present executive and operating officers who came up through the mechanical department are E. D. Bronner, vice-president and general manager of the Michigan Central; G. H. Emerson, general manager of the Great Northern, and M. K. Barnum, assistant to the vice-president, B. & O.

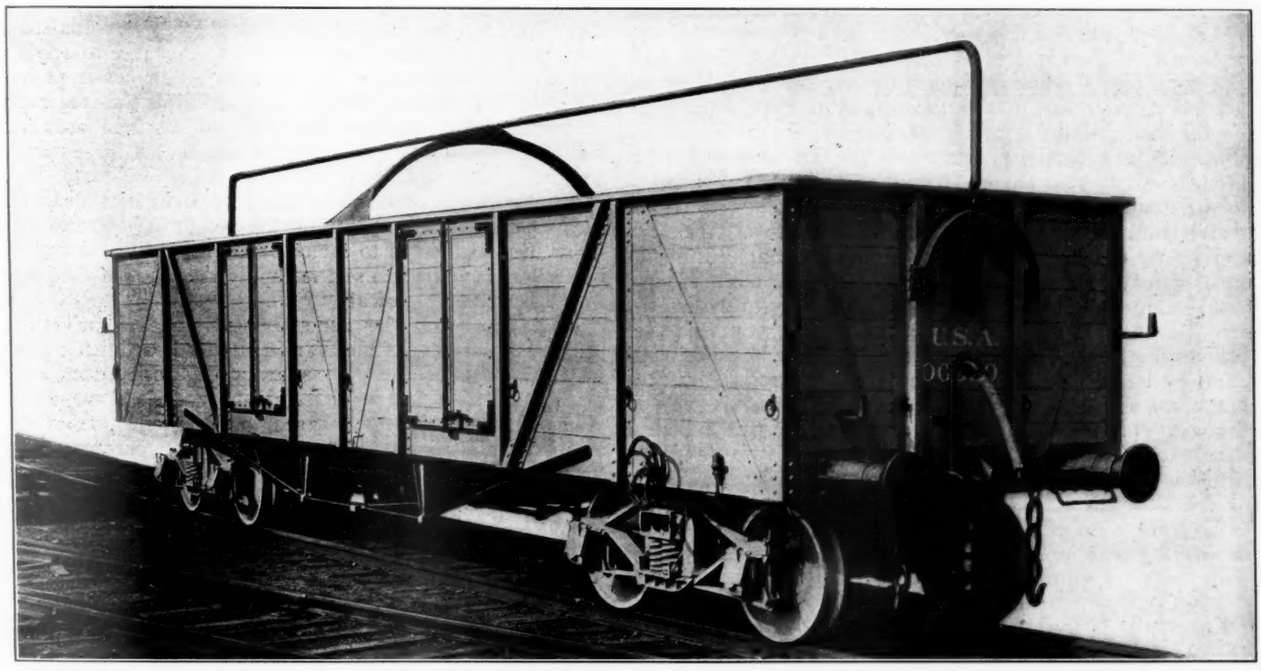
Before leaving railroad service F. A. Delano, now on the Federal Reserve Board, rose to the presidency of the Wabash, and later of the Chicago, Indianapolis & Louisville. W. H. Marshall was general manager of the Lake Shore & Michigan Southern, and John E. Muhlfeld was vice-president and general manager of the Kansas City Southern.

We must not forget Frank W. Morse, was preceded Mr. Robb as superintendent motive power of the Grand Trunk and was vice-president of that system, and later of the Chicago & Alton, and the Toledo, St. Louis & Western; nor Jacob N. Barr, who was superintendent of motive power of the Chicago, Milwaukee & St. Paul, Baltimore & Ohio, the Erie, and later became assistant to the president of the Chicago, Milwaukee & St. Paul; nor G. L. Potter, who came up through the mechanical department and finally became a vice-president on the Baltimore & Ohio.

THE CAR AND LOCOMOTIVE MARKET

Railway Supply Field Concentrates on Orders for the Government. More Cars Will Likely Be Ordered

THE car builders have completed the first car on the government orders for about 12,000 cars for the American forces overseas. The car shown in the illustration is a standard gage high side gondola and is one of the original order of 6,000 standard gage cars reported in last month's issue. The car has a capacity of 33 tons as compared with the usual four-wheel French car of not over 20 tons capacity. It is 30 ft. in length, its cubical content is 1,386 cu. ft., and its weight is 32,800 lb. The car body is built largely to French standards with side buffers and screw couplings, the last being necessary as it will operate with French rolling stock. It is, however, carried on American arch bar trucks, with standard M. C. B. journal boxes, and is fitted with standard American air brake equipment. The rod over the top of the car is to support a tarpaulin to protect the car contents, this rod being adjustable so that it may be swung down along the side when necessary.



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United States Government Car Built for Service in France

The United States Government since August 18 has placed orders for 680 standard gage Consolidation locomotives, 195 narrow-gage Prairie type steam locomotives and 189 narrow-gage gasoline locomotives, all for service in France. It has also on order 9,000 standard gage freight cars on two different sets of orders and 3,997 narrow-gage freight cars. The Committee on Public Information is authority for the statement that "additional orders for both narrow and standard gage equipment are likely." This shows to what a great extent the United States Government is depending upon the railway supply field to help in the war.

A glance at the figures of recent car and locomotive purchases will show, however, that outside of these government contracts but few orders for cars and locomotives have been placed during the past two months by either the American railroads or the governments of foreign countries. The total orders for locomotives during the months of August and September were only 26 although it is a fact that the New York Central and the Norfolk & Western did reserve space in locomotive shops for something like 270 locomotives. The total orders so far this year, including these reservations, now amount to 3,770 as compared with 3,067 at this time last year. The 1917 figure includes the government orders for 680 standard gage and 384 narrow gage locomotives, 2,406 locomotives for domestic use as compared with 2,043 at this time last year and 1,310 locomotives for export as compared with 1,024 last year.

Exclusive of the government contracts mentioned above for 12,997 freight cars, there were ordered during August and September only 8,073 cars for domestic use and 197 cars for export. The total orders for domestic use at the end of September totaled 51,228 as compared with 67,364 at this time last year and 50,159 this time in 1915. The export orders this year now total 26,047 as compared with 20,675 this time last year and 30,275 in 1915.

It has been suggested that the American railroads might be called upon to send locomotives or freight cars overseas to France; in other words, to make the same sacrifices along this line that have been made by England. It is now beginning to be evident that this will probably not be done, partly because the American railroads are in no position to suffer the loss of this equipment, and also because there is considerable question as to whether the American equipment could be used with the clearance of the railway lines in France. The railway supply field is being called upon to do what the railways might otherwise be called upon to do and the American railways should consider themselves fortunate that the supply field is in a position to carry out

this work. The American railways, however, will suffer seriously because they will be unable to get the locomotives that some of them have now had on order for some time. The government contracts will of course be given priority over all the business and it is likely that the contracts for foreign governments will come next. This may mean, for example, that a road which ordered locomotives four or five months ago for delivery next February may be able to get them, not in February, but if it is fortunate, seven months later, in October.

This brings us to the matter of prices. The recent reduction in prices of steel will therefore apparently have no definite effect upon the American railroads' opportunity to secure new equipment any sooner. The reductions in price may result in more orders for locomotives being placed but these orders will merely be added to those that are now on the locomotive building companies' books to be built in their turn.

There is good reason to believe further that the Russian Government, the French Government and possibly the British Government may also be coming into the market from time to time for engines in addition to those they already have on order and there are persistent reports in the trade that the placing of Russian contracts for large numbers of engines can be expected at almost any time.

Daniel Willard, president of the Baltimore & Ohio and chairman of the Advisory Committee on National Defense, brought this out in a paper that was abstracted in the September issue of the *Railway Mechanical Engineer*. It is worth while reproducing here again the conclusions that he brought out in that paper. "Shall we," he said, "in order to make our own task somewhat easier, to meet a situation that is undoubtedly pressing here, hold on to all the new engines we can build, facing the possibility that because of such action we may have to send 2,000,000 more of our young men to the battle line? Or shall we say to the builders, 'You send the engines that Russia wants, you send the engines that France and England want, and we by additional effort will undertake to carry the greatly increased burden put upon us, with what we already have'; that is why I ask you to be more careful of your power, to keep it in better shape, to get more out of it, to try constantly to do more with what you have. Not because we do not want to spend money, although that is a good reason, but because we want to send every available car and engine to our Allies so that on that account we will be called on to send fewer of our young men. I want you to think of that seriously."

REDUCTIONS IN PRICE OF STEEL

The car building plants in this country would have, under favorable conditions of a supply of labor and material, a capacity of 300,000 cars a year. It has been noted above that the total orders for cars this year including domestic, foreign and United States Government orders, have added up only to 90,272, only one-third of the total of the capacity. The buying of freight cars has been seriously handicapped by the high prices for equipment and it is to be supposed that the reductions in the price of steel may have some effect on the placing of orders by the railways for 1918 delivery. It is true that there may also be further orders by our own and foreign governments but in view of the fact that some of the plants have only been operating to 30 and 50 per cent of the capacity it can be seen that the chances for getting new cars is much better than the chances for getting new locomotives. The reductions in the prices for steel were announced on Monday, September 24. The reductions were the result of a more or less voluntary agreement of the steel producers with the War Industries Board and were based on the cost of production figures as ascertained by the Federal Trade Commission. The prices, which will apply alike to purchases by the government, the Allies and the public which includes the railroads as large users of steel, become effective immediately subject to revision on January 1, 1918, and are as follows:

Commodity and Basis	Price agreed upon	Per cent of reduction
Iron ore, lower lake ports	*$5.05	....
Coke, Connellsville	† 6.00	....
Pig iron	*33.00	43.1
Steel bars, Pittsburgh, Chicago	‡ 2.90	47.3
Shapes, Pittsburgh, Chicago	‡ 3.00	50.00
Plates, Pittsburgh, Chicago	‡ 3.25	70.5

* Gross tons. † Net ton. ‡ Hundredweight.

It is understood that these prices will not affect existing contracts, but that they will probably be of more immediate benefit to the railroads than the coal prices recently fixed, which applied only to the 20 to 25 per cent of the supply uncontracted for and which in many cases were higher than the prices agreed upon in long term contracts of large consumers.

The agreement stipulated that there should be no reduction in wages and the steel men pledged themselves to exert every effort to keep production up to the maximum.

One of the big problems encountered was similar to that so often discussed in consideration of railroad rates, involving the question of how to fix prices that would enable the small mills to produce without loss while preventing the larger plants from making too great a profit. It was settled by a plan which there has been great reluctance to apply to the railroad situation, of attempting to allow a fair price to the smaller producers, even if it does allow the larger producers a greater profit, but this decision was facilitated from the government standpoint by the fact that a large part of the profits may be taken by taxation.

Measures will be taken by the War Industries Board for placing orders and supervising the output of the steel mills in such a manner as to facilitate and expedite the requirements for war purposes and to supply the needs of the public in the best interests of all.

Coincident with the announcement of steel prices, the priorities committee of the War Industries Board made public its first general priority circular, giving instructions as to priority in orders and work for all individuals, firms, associations and corporations engaged in the production of iron and steel, and in the manufacture of their products. The committee is composed of Judge Robert S. Lovett, chairman, Major General J. B. Ayleshire, George Armsby, Rear Admiral M. E. Mason, Edwin B. Parker, J. Leonard Replogle and Rear Admiral A. V. Zane.

Under the regulations all orders and work are divided into three classes. Class A comprises war work, i. e., orders and work urgently necessary in carrying on the war. Class B comprises orders and work which, while not primarily designed for the prosecution of the war, yet are of public interest and essential to the national welfare, or otherwise of exceptional importance. Class C embraces all other orders and work. All orders will be classed as Class C unless covered by certificates to be issued by the committee. Orders and work in the other classes will have precedence and classes A and B will in turn be separated into subdivisions composed of orders regarded respectively as of greater moment and to be given precedence in accordance with serial number. Certificates will be issued upon application specifying the classification of the order or work. Certificates of a subsidiary nature will be issued upon request for the furnishing of material and articles required in manufacturing the article or prosecuting the work ordered. War orders of the Allies, as well as of the United States, will be placed in Class A in the case of those already contracted for. Orders previously placed by the War and Navy departments or the Shipping Board will be classed as subdivision A-1 of Class A unless otherwise ordered. Orders already placed by the Allies for war materials will be classed as subdivision A-2 of Class A unless otherwise ordered.

DESIGN OF HEAVY HELICAL SPRINGS

A Study of Spring Deflection with Computations for Single and Nest Springs, and Illustrative Examples

BY G. S. CHILES AND R. G. KELLEY

II

[The first part of this article was published in the September *Railway Mechanical Engineer* on page 477, of which the last five paragraphs are repeated here on account of an error in the text.—Editor.]

In designing an inner coil to work with the coil of Example 3, that is to conform to the same free and solid heights, and the same fibre stress, it will be necessary to maintain the same ratio of $\frac{D}{d}$ which, for the outer coil, is 3.40.

The outside diameter of the inner coil, allowing 1/8 in. clearance, will be 2 7/8 in.

Selecting at random a value of d for the inner coil of, say, 3/4 in., we obtain the following results:

$$D = D_o - d = 2.875 - .75 = 2.125 \text{ in.}$$

$$\text{and } \frac{D}{d} = \frac{2.125}{.75} = 2.83$$

Let us see what would result if a value of 2.83 for $\frac{D}{d}$ was used for the inner coil, and 3.40 for the outer coil. Assuming the solid and free heights of 9 3/4 in. and 12 in. were adhered to for the inner coil, the fibre stress when solid would be 115,300 lb. per sq. in. instead of 80,000 lb. per sq. in. as for the outer coil. The free height of this coil could be decreased in proportion to the increase in $\left(\frac{D}{d}\right)^3$, or to give a deflection of

$$\frac{2.83^3 \times 2.25}{3.40^3} = 1.57 \text{ in.}$$

making the free height

$$9.75 + 1.57 = 11.32 \text{ in.}$$

The fibre stress could also be decreased by increasing $\frac{D}{d}$. Since the outside diameter of this inner coil is limited, due to the inside diameter of the outer coil, the value of $\frac{D}{d}$ can only be increased by decreasing the value of d. With a 11/16-in. bar the value of $\frac{D}{d}$ is 3.18 and 3.60 for a 5/8-in. bar. Using the same free and solid heights for the inner coil as for the outer coil the 11/16-in. and 5/8-in. bars would have a fibre stress when solid of 91,400 and 71,600 lb., respectively. In case the 91,400 stress in the 11/16-in. bar was considered too high, the free height could be reduced, 1/8-in. reduction or a free height of 11 7/8 in. would give a maximum fibre stress of 86,300 lb., while 1/4 in. reduction or a free height of 11 3/4 in. would give 81,200 lb.

As a simple illustration let us assume a value for d of 7/8 in. Then it will be found that:

$$\frac{D}{d} = \frac{4.125 - .875}{.875} = 3.715$$

which is still too large. Selecting a 15/16-in. bar, we will obtain a value of $\frac{D}{d}$ equal to 3.41, a value which is sufficiently close for all practical purposes to that of the outer coil.

The following is an example showing how the free height may be determined when D_o, d, h, S and G are known:

Example 4:
Outside diameter = 8 in.
Diameter of bar = 1 5/16 in.
Solid height = 5 3/4 in.
Fibre stress when closed = 87,300 lb. per sq. in.

Substituting in equation (12),

$$H = \left[1 + \frac{3.1416 \times 87{,}300}{12{,}600{,}000}\left(\frac{6.4375}{1.5625}\right)^2\right] 5.75,$$

$$H = [1 + 0.0218\ (4.12)^2]\ 5.75,$$
$$H = [1 + 0.0218 \times 16.974]\ 5.75,$$
$$H = [1 + 0.370]\ 5.75 = 1.37 \times 5.75 = 7.878 \text{ in.}$$

The dimensions used in this example are those of the outer coil of the M. C. B. Class G spring, with the exception that 7 7/8 in. is the free height given.

To find the weight when the solid height is given. Since the cross sectional area of a round bar is equal to $\frac{\pi d^2}{4}$ it is evident that the cubical contents of the blunt length of the bar is equal to:

$$\frac{L \pi d^2}{4} \quad \ldots\ldots (16)$$

But from equation (2)

$$L = \pi\left(\frac{D}{d}\right) h$$

Therefore the cubical contents of the bar must be

$$\frac{\pi^2}{4} d D h \quad \ldots\ldots (17)$$

and assuming the weight of steel to be 486.6 lb. per cubic foot:

$$w = 0.695\ d D h \text{ (lb.)} \quad \ldots\ldots (18)$$

Various other formulae are in common use, but they all give practically the same results, the principal difference being due to the fact that different values are used for the modulus of torsional elasticity, and the number of effective coils.

In checking a "nest" of springs in order to determine the height for a given load it is necessary to determine the load which will compress each individual coil a fixed amount, preferably solid. One method, in which the calculated and test curves for a four coil spring are given, is illustrated in Fig. 9. The tabulated data in the upper right hand corner comprises all the information respecting the various coils. Each individual coil is calculated separately, the values being found in the order shown in the table. The theoretical curves are drawn in dotted lines, being merely straight lines joining the free height point with the point corresponding to the load required to compress the coils of the spring solid. The points to which the complete spring curve is plotted represent the sum of the values obtained by adding the values of the similar points of the four separate coils.

Each coil of a "nest" of springs built to the above specifications was tested and plotted as indicated, then the four coils were assembled and the complete spring tested. These theoretical or calculated and actual or test curves approximate each fairly close, the outer and second coils being slightly low near the top, while the outer coil goes solid at 7 3/4 in., or 1/4 in. higher than called for in the specification. This

action on the part of this one coil of course caused the complete spring to become solid at 7¾ in., and decreases the capacity of the complete spring some 2,000 lbs., inasmuch as it goes solid at 29,000 lb. instead of about 31,000 lb.

In Fig. 10 are shown the theoretical and actual test results for another four coil spring. The size of the bar for the various coils is the same as in Fig. 9, as is also the outer diameter, but the solid height has been increased 1½ in.; i. e., from 7½ in. to 9 in., and the free height of the three outer coils has been changed from 11⅛ in. to 13½ in., the inner coil only going to 13 in. A corresponding increase in y and n will be noticed. The values for $\frac{D}{d}$ and R are the same in Figs. 9 and 10, but the values for L, S and P are slightly different. The fibre stress of the three inner coils is slightly greater in Fig. 10, and the load correspondingly so, but the inner coil, due to a free height of only 13 in., has a smaller value for S and P than that of Fig. 9. While the total deflection of the inner coil in Fig. 10 is greater than that for the same coil in Fig. 9, (4 in. as against 3⅝ in.) the deflection per coil is as 4 divided by 20.57, and 3.625 divided by 17.14, or 0.194 in. per coil for Fig. 10, and 0.211 in. per coil for Fig. 9. Since $\frac{D}{d}$ is the same for each coil, the fibre stresses are to each other as the deflection per coil.

height. The load carried by the coil in question, and consequently that by the complete spring, can be altered by either of these methods.

The load on any coil can be varied in much the some manner, that is, either by increasing or decreasing the fibre stress; the load increasing directly as the fibre stress is increased and vice versa.

The following data may be instructive in that it brings out very forcibly the fact that, in the case of a spring composed of two or more coils having approximately the same value of $\frac{D}{d}$ and the same solid and free heights, the loads carried by each coil bear the same proportion to the total load as the weight of each coil does to the total weight of the complete spring:

Number of Coil	Outer	Second	Third	Inner	Complete Spring
Outside diameter .....(in.)	9½	6⅛	3⅞	2⅜	....
Diameter of bar.....(in.)	1⅜	1⅛	⅝	⅛	....
Weight of coil.....(lb.)	80	34	13	5	132
Weight carried by coil at a height of 10 in.....(lb.)	16,600	7,150	2,500	1,000	27,250
Per cent of total weight of spring.	60.6	25.8	9.8	3.8	100.0
Per cent of total load carried at 10 in.	60.9	26.2	9.2	3.7	100.0

Note.—Solid height 9 in. and free height 13 in. for all coils. Values for $\frac{D}{d}$ are the same as shown for coils in Figs. 9 and 10.

The above data was compiled by first calculating and then weighing and testing a spring built up of four separate coils, and it is plainly evident that the figures verify

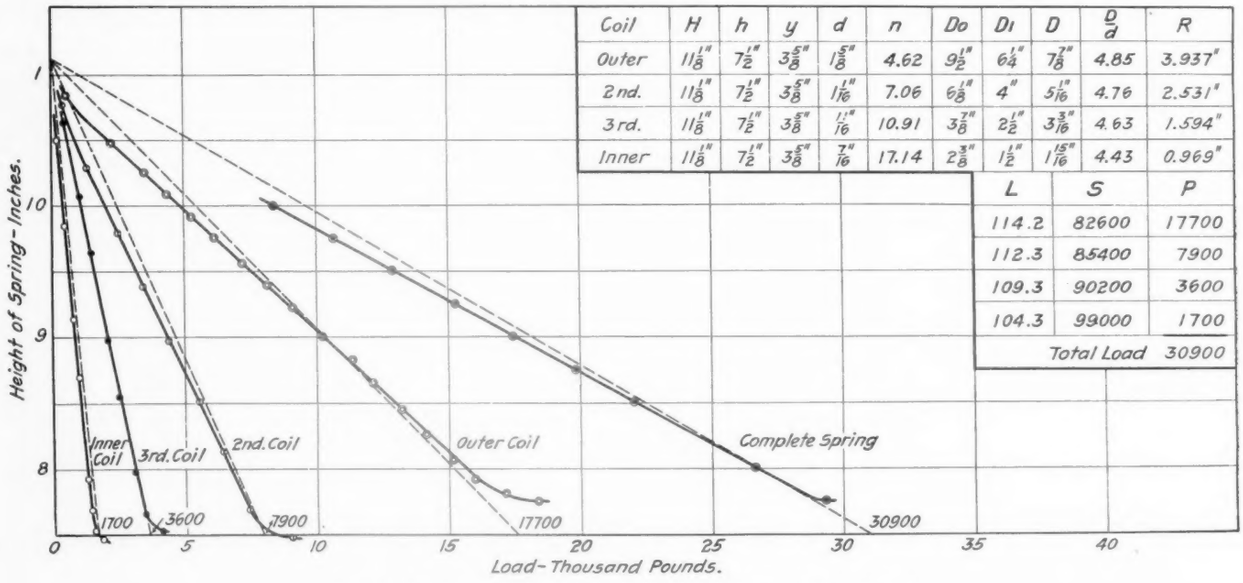

Fig. 9—Calculated and Test Curves for a Four Coiled Spring

In Fig. 9 the actual heights fell below the calculated heights for the two outer coils, and also for the complete spring while in Fig. 10 the actual heights are above the calculated heights for the two outer coils, and for the complete spring, but are below those for the two inner springs. Differences such as these can usually be, partially accounted for at least, if the various dimensions are checked carefully, and the actual values used in the calculation rather than the specified values as was the case in both Figs. 9 and 10.

It will be noticed that, as the ratio of $\frac{D}{d}$ becomes less, the fibre stress when the coils are solid increases; this is true only when H and h are equal. In case the fibre stress of one coil is too low, it is only necessary to increase the free height of that coil; if it is desired to decrease the fibre stress of one or more coils, it can be effected by decreasing the free

the statements just made. Thus, in line 4 of the above table we note that the weight of the outer coil is 80 lb. and the weight of the entire spring is 132 lb. Thus the percentage of the weight of the outer coil to the weight of the spring complete is 60.6 per cent, which is the value shown in line 6 of the column referring to the outer coil. Similarly, in line 5, we find that the weight carried by the outer coil when the spring has been compressed to a height of 10 in. is 16,600 lb., which is 60.9 per cent of 27,250 lb., the total weight carried by the entire spring when it stands at a height of 10 in. These values of 60.6 per cent and 60.9 per cent check each other very closely. Knowing the total load carried by the entire spring, the weight of each coil and the weight of the spring complete, this constitutes a simple method of determining approximately the load which will be carried by each coil.

In compression, as in tension springs, the load is exerted

axially, and any section of the bar is subjected to torsion. The twisting moment PR must equal the moment of the shearing stresses, or from equation (5) we get:

$$P\,R = \frac{\pi\,d^3}{16}\,S, \quad \ldots\ldots(19)$$

$$\text{and } S = \frac{P\,R}{\frac{\pi\,d^3}{16}} = \frac{16\,P\,R}{\pi\,d^3} \quad \ldots\ldots(20)$$

The formulae for torsional strength and stiffness given above are based on the polar moment of inertia, and polar modulus, but it should be kept in mind that they hold true only as long as the unit stress does not exceed the elastic limit of the material.

The assumptions used in developing the theory of torsion are not strictly applicable to any but circular sections. St. Venant found in his investigations on the strength of square and rectangular sections that the greatest stress and strain occurred at the middle of the (longest) side of the section.

STANDARDIZATION AND IMPROVED LOCOMOTIVE SERVICE

BY GEORGE ARMSTRONG

Standardization as reflected in past efforts of railroad equipment builders and designers has been aimed toward the securing of a more universal application of a few particular types of equipment. There are, however, other possible phases of standardization, applicable to existing equipment, and which, in the strenuous pressure of war times, deserve serious consideration. Material is difficult to obtain, manufacturing facilities are over-crowded, and transportation demands are such that every available source of power is required for the highest percentage of effective service.

Not only do the exigencies of war time operation demand that every effort be expended to keep transportation equipment in service, but this must be done with as small a drain as possible upon the other necessary industries. All unnecessary waste of labor or material, loss of time because of equipment unnecessarily standing idle, and every needless operation performed either in the transportation or manufacturing industries, is more than a waste affecting the individual or corporation—it is an economic waste affecting the nation. Never before have we had so forcefully impressed upon us the fact that our obligations are broader than the individual; in a new and larger way we are being brought to realize our obligations to the state and to society.

Effective service from equipment implies a minimum delay for repairs. This delay is the time necessary to perform the required repairs, the time for preparation of the needed material and the unnecessary time lost in waiting for material not available. Each contributing factor is susceptible of improvement

Methods for more efficient employment of labor have been expounded in the past and are, or at least should be, well known.

Delays due to material may be reduced by:

First: Group assignment of power to reduce the required stock of material.

Second: Standardization so that a stock of partially or

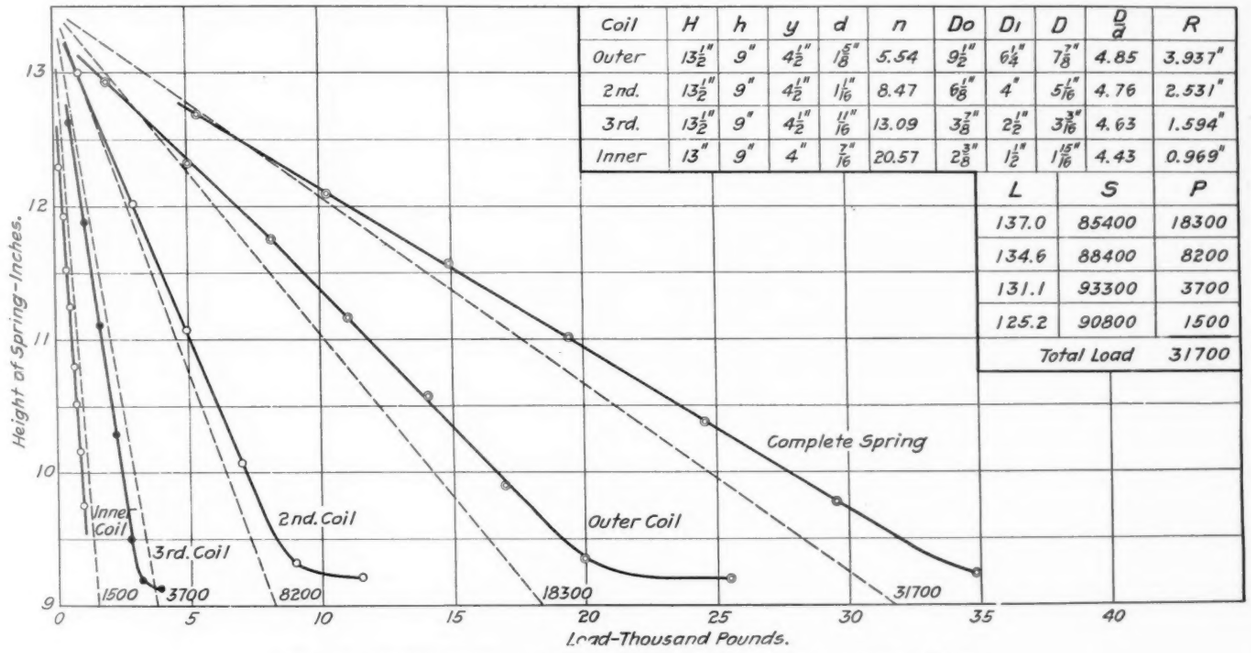

Fig. 10—Similar Curves to Those Shown in Fig. 9 for a Longer Spring

Using the values as found in his experiments for square sectioned steel, the following is obtained:

$$S = \frac{P\,R}{.208\,d^3} \quad \ldots\ldots(21)$$

$$P = \frac{.208\,d^3\,S}{R} \text{ or } \frac{.416\,d^3\,S}{D} \quad \ldots\ldots(22)$$

$$y = \frac{7.16\,P\,R^2\,L}{G\,d^4} \text{ or } \frac{1.79\,P\,D^2\,L}{G\,d^4} \quad \ldots\ldots(23)$$

$$y = \frac{45.00\,P\,R^2\,n}{G\,d^4} \text{ or } \frac{5.62\,P\,D^3\,n}{G\,d^4} \quad \ldots\ldots(24)$$

The weight of bar, $w = 0.88\,d\,D\,h$ (lbs.) where, d equals side or square.

Comparing the formulae for square section and circular section springs of equal areas (weight for weight) we find a closely coiled circular section coil spring of given diameter is almost 1.4 times as strong and will absorb 1.6 times as much energy as one of square section of the same diameter D.

LIFE OF CAST IRON PIPE.—The Illinois Central reports that some 6-in. cast iron pipe which had been in service for 40 years was found in such good condition on the relocation of its shops at Centralia that it was used again.

wholly completed parts centrally produced, may be maintained.

Third: Standardization of other parts not susceptible to centralized finishing, thereby reducing the required supply of raw work and the possibility of shortage.

ASSIGNMENT OF POWER.

Much needless duplication of stock is often necessitated by an assignment of power so that several engines of a small number comprising a class, or similar classes, are distributed over many divisions rather than group assigned to one division, or at least to a few divisions and those adjacent, if possible. Often there is no reasonable excuse why this equipment cannot be more compactly assigned, while a careful consideration and group assignment will often permit a substantial decrease in the idle investment in raw materials scattered over the railroad at numerous points for protection against failures. Each piece of material unnecessarily stored at some point, each piece unnecessarily used, is an additional drain on the industrial resources of the country, and prevents the production of some article which may be badly needed.

Needless demand for materials, however small, in the aggregate may be a powerful factor tending to increase the railroads' "cost of living," already disproportionately high. Every useless operation performed in the repairs to equipment adds to the increasing shortage of labor. The highest patriotic duty demands the utmost conservation of natural and industrial resources consistent with unimpaired efficiency of the transportation service.

One railroad having 35 Mikado type locomotives equipped with 8½-in. cross-compound pumps has this equipment scattered over various divisions, requiring the maintenance of repair parts for these pumps at eight points. One division alone has 56 Mikado engines assigned to it, and consequently it alone could easily utilize these 35 locomotives, thereby reducing the stock of parts required, as only the two terminals at the end of the division and the point shopping these engines would require repair parts.

Another example is the assignment of one class X-1 passenger locomotive on a division where part of another class of practically similar tractive effort and general dimensions is in use so that a locomotive of this latter class could have been transferred from another division and the class X-1 engine used on one of the four other divisions to which the remaining engines are assigned.

Six switching engines, class B-25, are distributed so that five are at one terminal and one at another terminal 500 miles removed. Ten class B-62 switching engines are distributed, nine at the same terminal as the B-25 noted above and one at a terminal 700 miles away. A distribution of class M-10, M-11, M-12 and M-13 Consolidation freight locomotives is promiscuously made over several divisions upon any one of which these particular classes will give equal service, as the engines are of practically the same proportion and tractive effort.

STANDARDIZATION OF PARTS.

Standardization of parts, as far as possible, has still greater possibilities for resulting in improved effective equipment than assignment of power. The multiplicity of parts required where no attempt is made at standardization often results in unnecessarily long delays in returning equipment to service when repairs are required. The benefits to be derived from standardization are:

First: Reduction of the investment in idle stock.

Second: Decrease in the possibility of waste through eventual scrapping of obsolete material.

Third: Greater possibility for checking consumption of material and eliminating waste due to improper maintenance factors.

Fourth: A substantial reduction in the cost of manufacturing standardized parts through centralized production*.

One railroad has three styles of 12-in. piston valves, one style of 13-in., two of 14-in. and one of 16-in. used on a total of 12 different classes of equipment. A slight modification of the various valves and bushings would allow the use of one 12-in. and one 14-in. valve to cover the requirements. The 12-in. valve could be adapted to the engines requiring 13-in. valves by increasing the thickness of the steam chest bushing. The 14-in. piston valve could be adapted to the cylinder requiring the 16-in. valve through similar means. These modifications would allow the machining of the bull rings, followers, valve body and packing rings at a central shop and they could be distributed to the various points requiring them. This cannot be done to advantage where seven valves are required, several of which are used on only a total of 20 or 25 engines. These modifications would not only effect a reduction in the cost of making these parts, but would often assist in a ready turn of power owing to the possibility of maintaining a stock of completely machined castings.

Under the existing conditions, these engines require 21 castings for the various valve parts, four for the piston valve packing rings and seven for the steam chest bushings, a total of 32. If modified, as outlined, only six different castings would be required for the valve parts, two for the packing rings, two for the bushings and two for the adaptor bushings mentioned for the 13-in. and 16-in. valves, a total of 12 castings.

Another item, a prolific cause of holding power where no attempt is made at standardization, is grate material. One eastern railroad has solved this problem by reducing its number of grate castings from 25 or 30 to 5 which fill the requirements from Santa Fe and Mallet type locomotives to the small locomotives with narrow fireboxes set inside of the frames. In addition to reducing the number of grate castings required, attention was also paid to the center and side bearing bars, resulting in a substantial reduction in the number of different castings required for this purpose.

Another eastern railroad has solved the oil cup and grease cup cover question by adopting one casting for all classes of power and for both oil or grease cups. When the cover is to be used on an oil cup, it has a small hole drilled through the center, otherwise it is only turned and threaded when used on a grease cup. This cover is adapted to the various sizes of oil cups by means of a renewable steel bushing manufactured in quantities on a turret lathe and which is either screwed into the rod or dropped into place and pinned or secured by electric spot welding. As the threads in this bushing can be maintained standard, the possibility of losing loose oil cup covers is materially lessened.

Another expedient adopted by a number of railroads, which is resulting in a considerable reduction in material and labor, is the short pilot made from scrap, either old flues or steel car parts. Many railroads still maintain the long nosed pilot projecting beyond the face of the coupler. Much needless destruction results, due to contact between two pilots of engines head-end on at an ash pit or at other points around terminals. In addition to overcoming this loss, the short pilot is considerably cheaper to manufacture.

Crosshead and knuckle pins afford another large possibility for standardization and consequent economy in the use of material. Often slight variations in the diameter or length, or even in the thread of the nut are made which cannot be justified. These pins are admirably adapted for quantity production on a high duty turret lathe from old axles without any work being required to draw them down. These steel axles are otherwise serviceable only as scrap, as

* See *Railway Mechanical Engineer*, June, 1917, page 289.

the large amount of scrap steel axles accumulated on the average railroad in the course of a year cannot all be utilized in making small forgings. The production of these in large quantities, roughed down in two sizes to within either a quarter or one-half inch of the finished size ready to be fitted, as is one railroad's practice, will often assist materially the outlying terminal in quickly returning power to service instead of its being necessary to forge a pin under the hammer, or waiting until one is obtained from the nearest shop.

Front, back and intermediate crank pins can also be made in this manner, being finished complete with the exception of the wheel fit. Driving boxes, shoes and wedges, cylinders, smoke stacks, exhaust nozzles, injectors, air pumps and air brake fittings, truck side frames, crossheads, valve gear parts and numerous other parts present possibilities for standardization and substantial economy in maintenance costs and reduction in terminal delays.

The subject of group assignment of power, standardization of parts and centralized production has always afforded substantial reward for serious consideration, but their possibilities are particularly advantageous under present conditions. While standardization applied to existing power might seem expensive when viewed in the aggregate, its value, particularly when accomplished at the time locomotives are overhauled, will warrant the most serious consideration.

RAILWAY ENGINEERS NOW IN FRANCE

Press Despatches Tell of Interesting Experiences of the American Corps in London and at the Front

"BY day and by night the men of the American regiment of engineers which has taken over a nimportant line of French strategic railways are hauling tons upon tons of ammunition and other supplies to the French army units operating against the Germans.

"The American regiment," continues an Associated Press despatch, "has been turned over as a unit to the French and is getting all its supplies except clothing from the French government. The officers and men entered upon the work with the greatest enthusiasm, and they have been under German bomb and machine-gun fire from airplanes.

"Within the last few nights a heavy train of supplies hurrying toward the front was attacked by several enemy planes. None of the bombs came dangerously close, but every time the fire-box of the engine was opened for stoking the planes swooped down upon the train and spattered it with steel-jacketed bullets.

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The Stars and Stripes at the Head of the Engineer Corps—London

"This fire got so hot that eventually the train was stopped, the crew taking refuge beneath the engine. Relating their experience afterward these trainmen rather 'swanked' about it over their inexperienced brothers.

"The spirit of adventure is strong throughout the American ranks and the engineers who so far have not been bombed are openly jealous of their more 'fortunate' comrades. So far none of the regiment has been under shell fire, but the men may yet have a taste of the noisy German 5.9s and the whistling 'Percys,' 'Wooly Bears' and 'Whiz-bangs.'

"There is a great spirit of comradeship among the officers and men, most of whom have worked together and have known each other for years. The regiment is known as an operating unit as opposed to the engineers enlisted as construction units.

"Before proceeding to the front the regiment was quartered in a little French town within the zone of the French army. The arrival of the Americans at this town was kept secret and they marched into the place late at night after all lights had been extinguished. The soldiers were not allowed to smoke, strike matches or say a word. Despite the stealthy entrance, however, the French townspeople knew quickly of the arrival and soon the streets were filled with a quiet throng which joined in among the Americans and paraded with them arm in arm.

"It was one of the strangest welcomes any troops probably ever received anywhere, but it was at the same time one of the most sincere."

THE PARADE IN LONDON

Before landing in France, the railway engineers were in England. They were in training for a time and paraded through London. A London newspaper clipping received from one of the American engineers indicates what a holiday the English made of this parade:

"Very early in the morning people discovered their viewpoints and waited patiently watching the enormous crowds that joined us. Traffic was diverted or stopped altogether. Shops were shut and business suspended and later the meeting of the War Cabinet itself was adjourned so that the prime minister and his colleagues might become as the people of the streets making greeting to the men who 'mean to see it through.' . . . Londoners are not very ready to cheer. Theirs is the way of silent tribute. But yesterday they forgot the silly traditions of British reserve. They might have been Irish or Italian in their wild enthusiasm. For, as the first Americans were seen, cheers were raised such as have never been heard in London. . . . Louder and still louder rose the cries as the Stars and Stripes came in view. Soldiers in the crowd saluted; men raised their hats, and women threw their flowers and waved their handker-

chiefs—and some of them sobbed happy tears of pride such as no man or woman need remember with shame."

NEW ENGINEER REGIMENTS TO BE RAISED

Almost coincident with the news that the railway engineer regiments are now at work in France comes the news that there will be organized additional engineer regiments and that the present nine railway regiments will each be increased in size.

In General Order No. 108, just made public by the war department, the President directs that there be organized for the period of the existing emergency, the enlisted strength being raised and maintained by voluntary enlistment or draft, special and technical engineer troops, including six regiments, and additional smaller units of engineers for each army and 14 regiments for the line of communications, the organization of the latter being under the direction of S. M. Felton, director general of railways.

The authorization for the line of communications, which includes the nine railway regiments already organized, but also provides for an increase in the number of men in each company, from 180 to 250, is as follows:

1. A general construction service, consisting of the following: 1 regimental headquarters, 6 engineer companies (construction), 6 service battalions (4 companies each).

2. An engineer supply service, consisting of the following: 1 regimental headquarters, 2 battalions of engineers (supply) of 3 companies each, 2 battalions of engineers (workshop) of 3 companies each, 3 service battalions (4 companies each).

3. A forestry service, consisting of the following: 1 regimental headquarters, 10 battalions of engineers (forestry) of 3 companies each, 9 service battalions (4 companies each).

4. A quarry service, consisting of the following: 1 regimental headquarters, 2 battalions of engineers (quarry) of 3 companies each, 3 service battalions (4 companies each).

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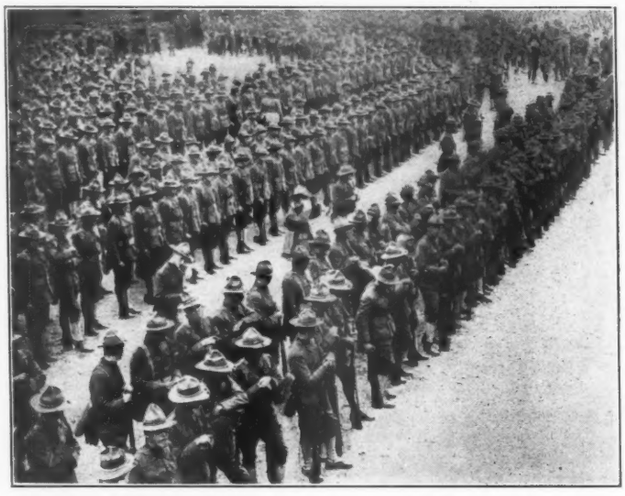
American Soldiers Passing over Westminister Bridge, London

5. A light-railway service, consisting of the following: Construction department, 1 regimental headquarters, 5 battalions of engineers (railway) of 3 companies each, 3 service battalions (4 companies each); operation and mechanical department, 1 regimental headquarters, 4 battalions of engineers (railway) of 3 companies each, 3 service battalions (4 companies each).

6. A standard-gage railway service, consisting of the following: Construction departments, 5 regiments of engineers (railway) (the 11th, 15th, 16th, 17th and 18th engineers, railway, National Army), 8 service battalions (4 companies each); operation and maintenance department, 2 regimental headquarters, 6 battalions of engineers (railway) of 3 companies each, 3 service battalions (4 companies each); mechanical and supplies department, 1 regiment of engineers (shop) (19th engineers, railway, National Army), 1 battalion of engineers (railway) of 3 companies, 1 service battalion (4 companies).

Of these the regiments for the general construction service, the engineer supply service, the forestry service, and the light railway service are new. The 9 regiments already organized are the 11th to the 19th, inclusive. The 20th engineers (forestry) is being formed at American University, Washington, D. C. The 21st engineers, for construction of light railways, is being organized at Camp Grant, Rockford, Ill., under Col. Edward Peak, with H. J. Slifer, consulting engineer and formerly general manager of the Chicago Great Western, as lieutenant colonel.



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A Rest After the Enthusiastic Parade

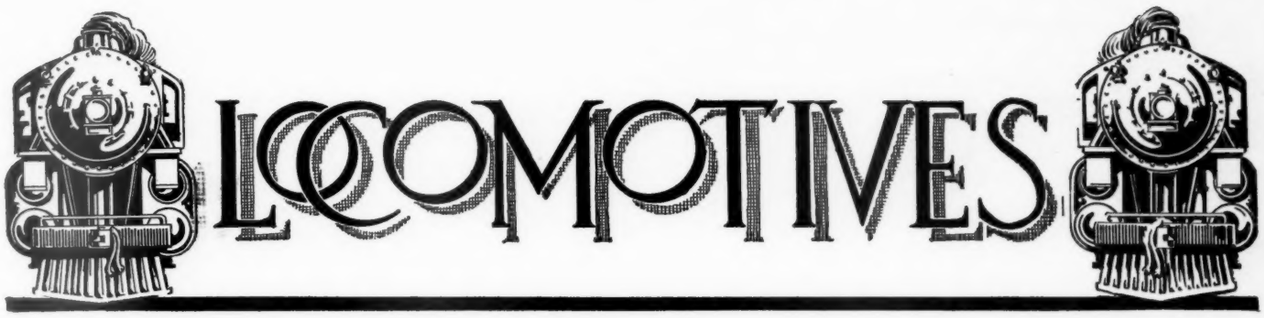
Service battalions will be transferred from one service to another as may be necessary. Engineer troops of a special service may be utilized in another engineer service in the discretion of the commanding general concerned.

Railway operating and shop troops, forestry troops, and service battalions will be equipped as infantry, but only 10 per cent will be armed, except during training, when all will be armed; non-commissioned officers of these organizations will be armed with pistols. All other special engineer troops will be armed as divisional engineer troops.

The National Army cantonments will be utilized for the organization of the units herein authorized. The cantonment at which each unit is to be organized will be determined by the chief of engineers after consultation with the quartermaster general. When necessary for special engineer training, these organizations may be sent to one of the regular engineer training camps.

The selection of officers for these regiments is under the direction of Mr. Felton, Capt. E. N. Sanctuary of his staff being in charge of matters of personnel. Railway men who have been drawn under the terms of the selective service act may be transferred to the engineer regiments.

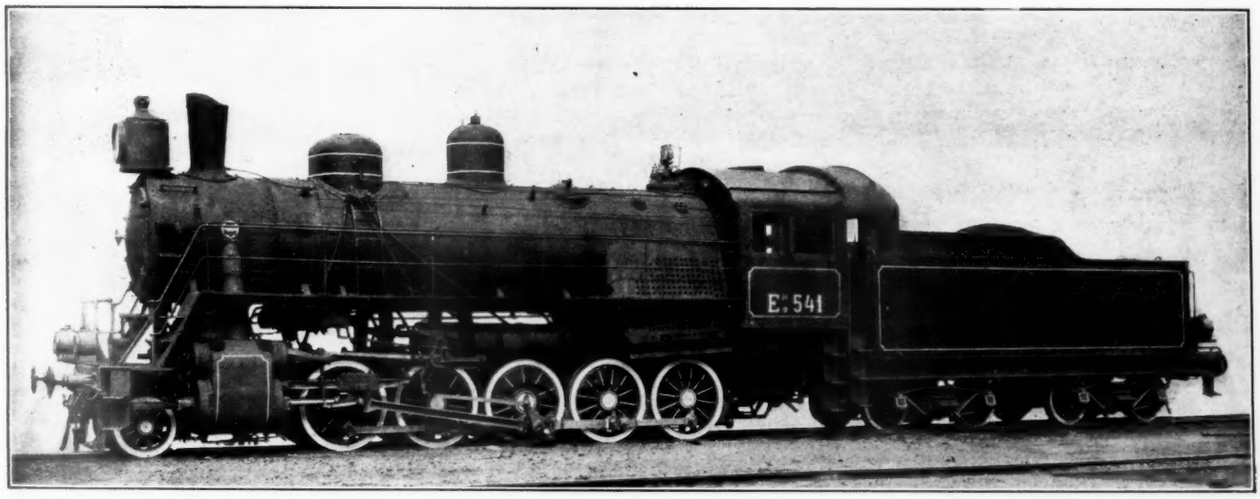
Russian Railway Loan.—The Petrograd newspapers announce the forthcoming issue of a second so-called railway loan. The money will be used for 17 railway companies which have been taken over by a syndicate of banks. The loan will be for rbls. 750,000,000 ($386,000,000), the rate of interest 4½ per cent, and the price of issue 81 1/3.



RUSSIAN DECAPOD LOCOMOTIVES

Built in America for Russian Government; Important Russian and American Practices in the Design

ONE of Russia's most imperative needs, at the present time, is increased transportation facilities. Additional motive power and rolling stock are urgently required, and American manufacturers are furnishing locomotives and cars in large numbers, as rapidly as facilities will permit. Since the summer of 1914 the total number of heavy freight locomotives ordered by the Russian Government railways from the Baldwin Locomotive Works and the American Locomotive Company is 1231, the former company furnishing 725 and the latter 506. These engines probably constitute the most notable group of heavy power ever shipped by American locomotive builders to a foreign country. Those last ordered will be completed during the year 1918. In addition, 50 locomotives of similar type have been supplied by the Canadian Locomotive Company.



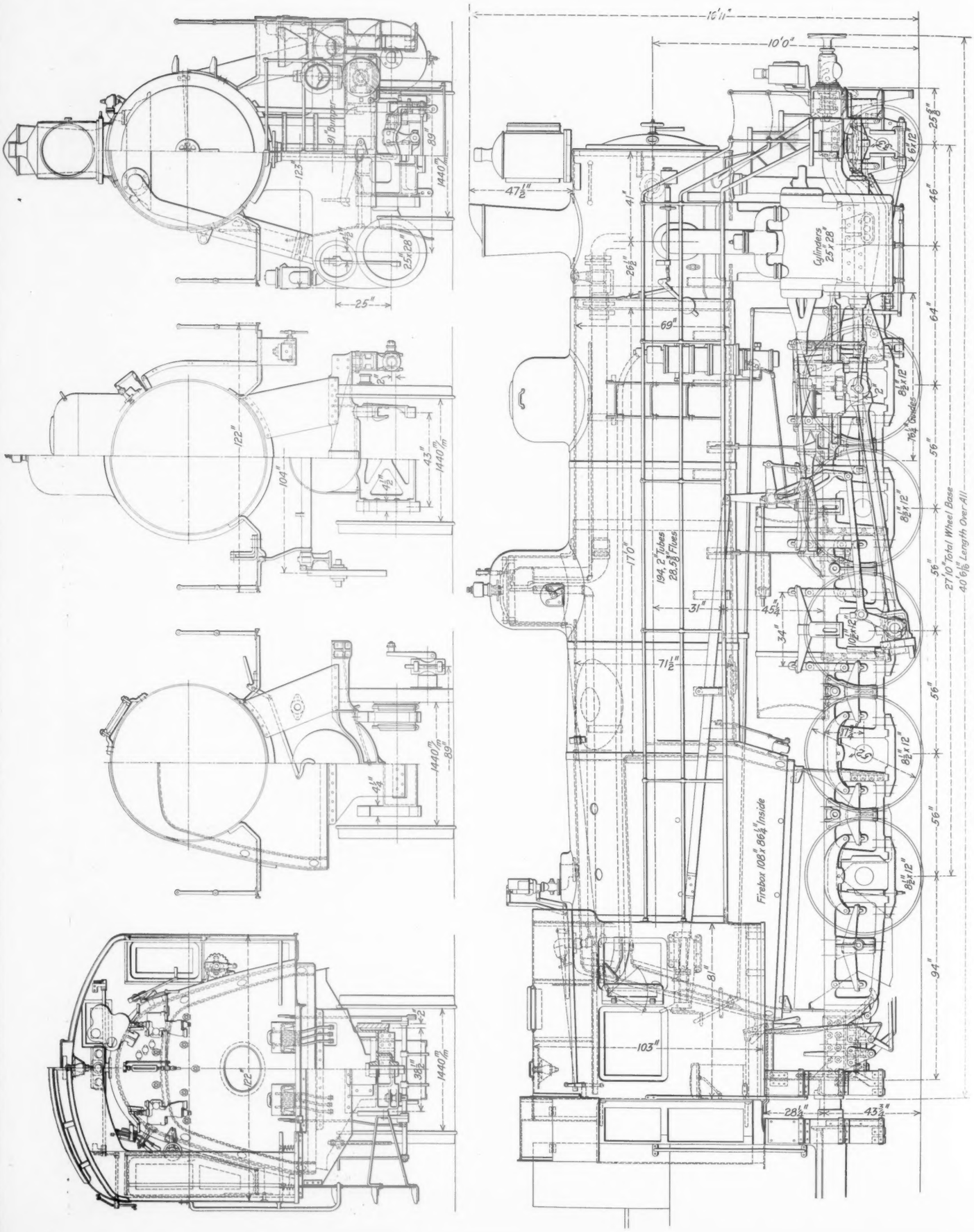
Russian Government Decapod Locomotive

The design and construction of these locomotives were under the direction of A. I. Lipetz, chief of the locomotive division of the Russian Mission on Ways of Communication in this country. They have been built on a number of different orders; but, although the later engines present various changes in details, as compared with those first constructed, the locomotives are all of the same general design and hauling capacity. The wheel arrangment is 2-10-0, and the tractive force exerted is 51,500 lb. The maximum load per driving axle is limited to 16½ metric tons. The locomotives are designed to operate on curves of 700 ft. radius on the main line and 350 ft. on sidings, and to handle 1,300 metric tons up a grade of 0.8 per cent, at a speed of 8 to 10 m. p. h. They have ample capacity for doing this, while working at a fairly economical cut-off.

The locomotives now being built by the Baldwin Locomotive Works and the American Locomotive company are identical in construction. In general design they follow American practice, although many of the details are in accordance with Russian standards. The Russian engine crews can, therefore, handle them without difficulty.

The boiler is of the straight top type, with a wide firebox which is placed above the rear pair of driving wheels. The boiler center is placed 10 ft. above the rail, and this allows ample room for a deep throat, and for the installation of a Security sectional arch supported on water-tubes. The firebox is radially stayed, and a total of 462 flexible stays are used in the water legs. Of these, 286 are placed in the sides; 84 in the backhead and 92 in the throat. In addition, four transverse rows of expansion stays support the front end of the crown and one row is used at the back.

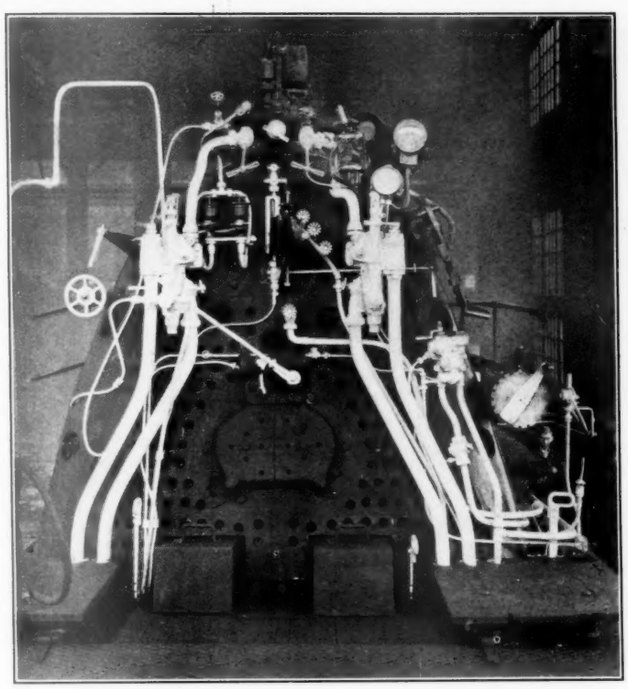
The equipment of hand-holes and wash-out plugs is unusually complete; and a man-hole, 15½-in. in diameter, is placed on the round of the boiler on the left hand side, just forward of the firebox. The dome is of the built-up type, with an inside diameter of 30 in. Three safety valves are provided, one of these being mounted on the dome cap, and



Elevation and Sections of the Russian Decapod Type Locomotives

the other two on a specialy designed turret, placed over the firebox and immediately in front of the cab. Two whistles are also mounted on this turret, and the rigging is so arranged that one of them can be blown from the train, by means of an outside cord connection.

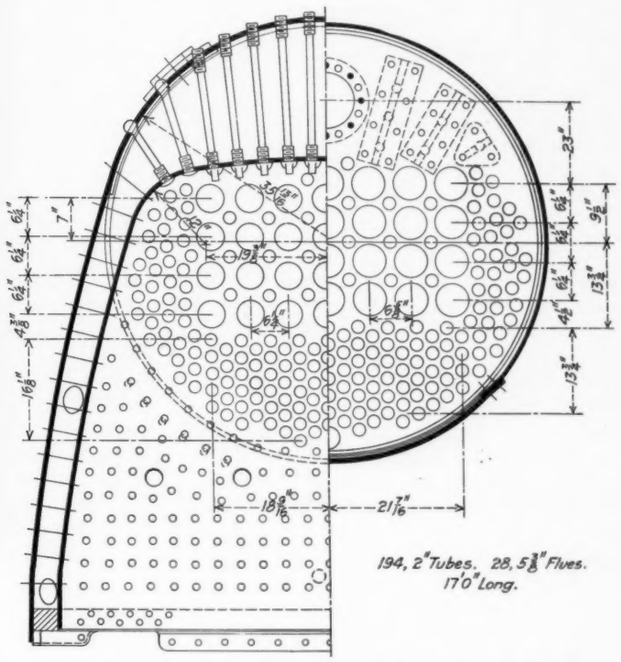
The throttle valve is of the sliding type, in accordance with



A View of the Back Boiler Head with the Cab Removed

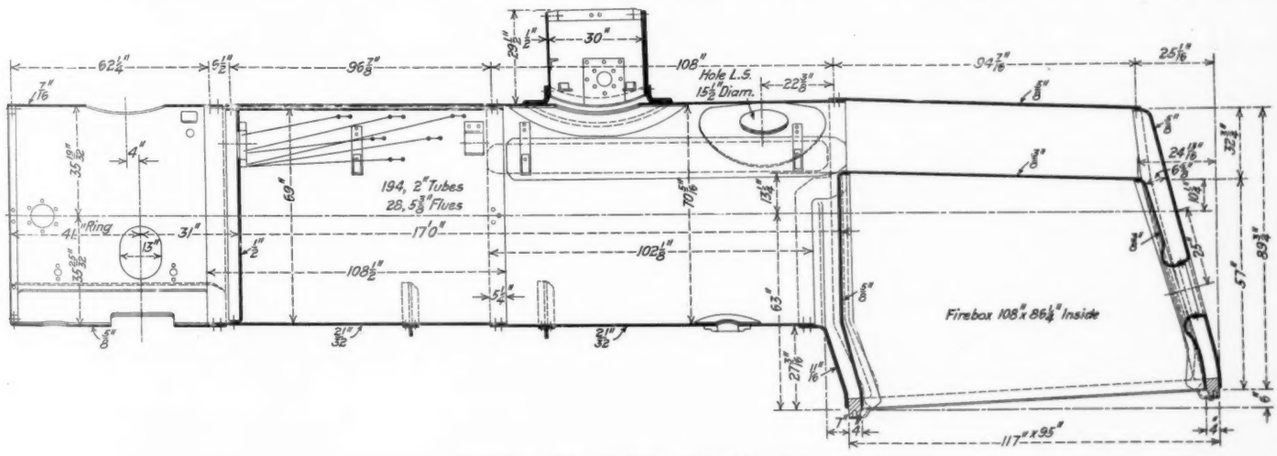
Russian practice with a small auxiliary valve which opens first, facilitating the opening of the large valve and this same small valve is used when drifting on engines which have no by-pass valves. It has outside connections with the lever in the cab and is arranged to open with a downward movement of the slide. There are two ports in the vertical throttle-pipe, and they are tapered in width, so that a very small opening can be obtained. Springs are provided to assist in holding the slide against its seat.

These locomotives use superheated steam, and are equipped with a 28-element fire-tube type superheater. The superheater damper is arranged with several openings, which are placed in the front wall of the box enclosing the header. This construction replaces the single damper opening in the bottom of the box, which is ordinarily used in American locomotives. The cylinders are of the two-piece type, designed in accordance with American practice. The steam distribution is controlled by 12-in. piston valves. These are fitted, at each end, with light cast steel heads and spiders, between which is placed a cast-iron bull ring. The heads and spiders are mounted on the valve stem, which is extended through the front head. The packing rings and steam chest bushings are of gun-iron. The Walschaert valve gear is applied,



Half Sections Through the Firebox and Smoke Box

in combination with a screw reverse mechanism of Russian type. The pistons are of rolled steel, with extended piston rods, and the crossheads are light steel castings sliding on single bar guides. The back end of the main rod is fitted with a forked stub of Russian design. A steel filling piece is slipped over the fork between the brass and the key and this filling piece is fitted with a lug through which pass the two key adjusting bolts.

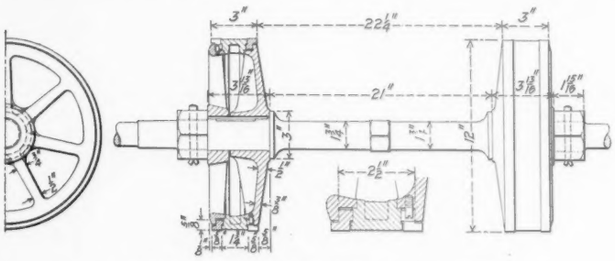


Boiler of the Russian Decapod Type

Some of these locomotives are equipped with the Zyabloff by-pass valve. This device is arranged with a pipe connec-

Elevation and Sections of the Russian Decapod Type Locomotives

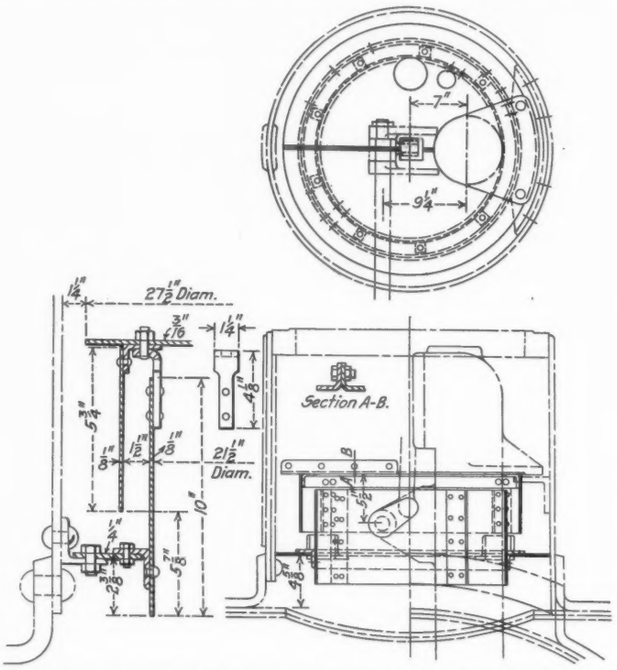
tion 4 in. in diameter, which communicates with the steam ports at each end of the cylinder. In the center of this connection is placed a vertical plunger, formed in one piece with two pistons. When the throttle is open, steam acts on the power piston, pushing the plunger up against a spring, and closing communication through the pipe connection. When the throttle is closed, and the steam pressure is relieved, the spring forces the plunger down, and there is free communication between the two ends of the cylinder. Another device of



Piston Valve for the Russian Locomotives

special interest is the Shukaloff drifting or vacuum relief valve, which is used in conjunction with the Zyabloff by-pass valves. This valve communicates with the superheated steam section in the smoke-box header. When the engine is using steam, the pressure forces the valve down and holds it shut. When, however, the engine is drifting and a vacuum is created in the steam passages, the valve rises from its seat and air is admitted through a suitable strainer. At the same time, a pipe connection is opened, through which a small quantity of saturated steam is admitted to the superheater header, and thence to the cylinders. This assists in breaking the vacuum and in keeping the valves and pistons properly lubricated.

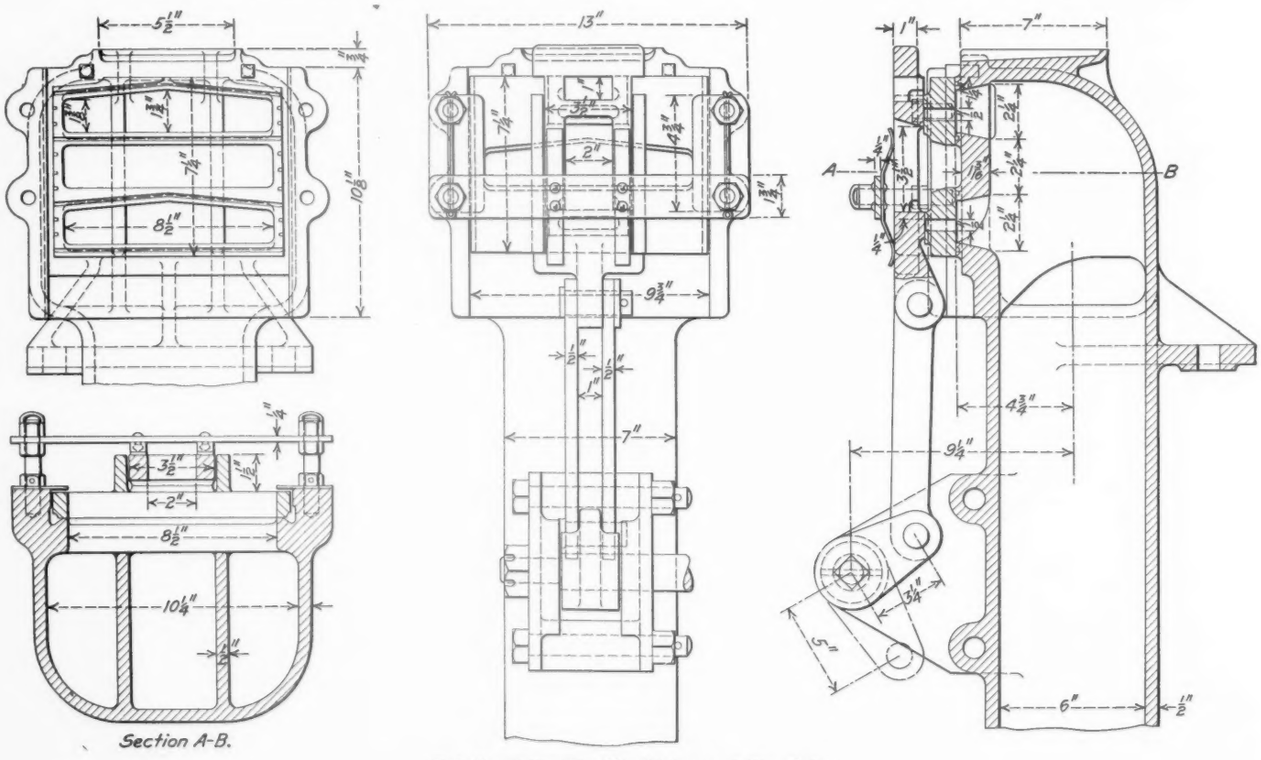
cone, which can be raised or lowered. When in its top position, all the exhaust steam passes out through the interior of



Steam Drying Baffle Plates in the Dome of the Russian Locomotives

the frustum; and when it is lowered, an annular opening around the frustum is provided in addition.

The frames are vanadium steel castings, 4½ in. in width,

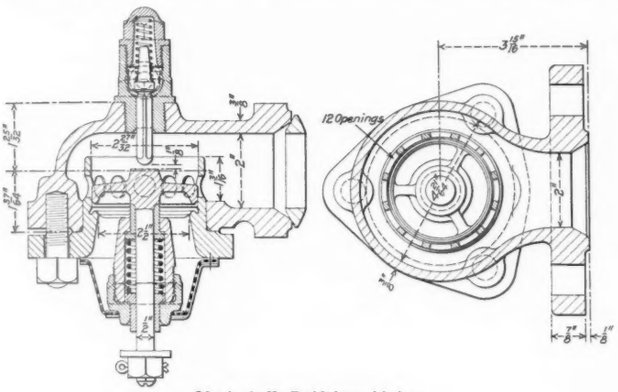


Details of the Throttle Valve and Standpipe

The exhaust opening is variable and is worked, through suitable connections, by means of a hand-wheel placed in the cab. The exhaust nozzle contains a hollow frustum of a and placed 43 in. between centers. The equalizing rigging is anchored to the frames between the third and fourth pairs of drivers, but is so arranged that, if desired, it can be

changed and anchored between the second and third pairs. The leading truck is equipped with three point suspension links, and is equalized with the drivers in the usual manner.

The driving-wheel centers are turned to metric measurements, and the tire widths and transverse spacing also conform to the metric system. The wheels are designed to balance approximately 45 per cent of the weight of the reciprocating parts. The driving tires are shrunk on the centers,

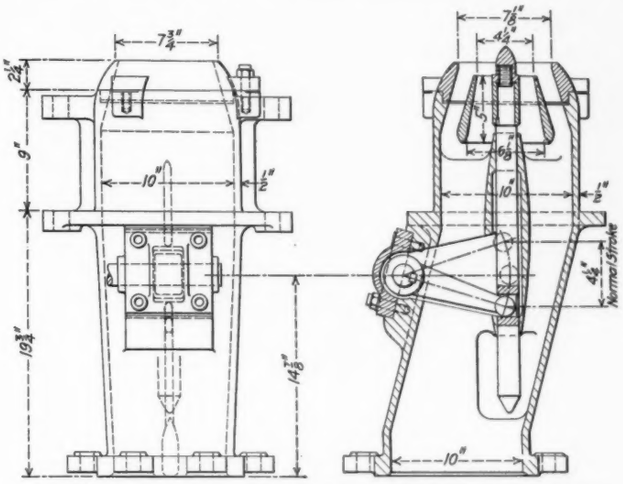


Shukaloff Drifting Valve

and are held by set screws and retaining rings in addition to the usual shoulder. The tires of the third, or main pair of wheels, are flangeless.

The front bumper is of steel built up, and screw couplings and spring buffers are applied in accordance with Russian railway practice. Two large signal lamps are placed on the front bumper when running forward and at the rear end of the tender when running backward, while the headlight is mounted on top of the smoke box.

Included in the equipment of these locomotives, are Russian-Westinghouse automatic air brakes, LeChatelier cylinder water brakes, electro-pyrometer for indicating superheated steam temperatures, and a six-feed mechanical lubricator. The injectors are of the Russian vertical type, and are mounted on the back head. In connection with them, sprinklers are applied for the ash-pan, smoke-box and cab deck. Power-operated fire-doors have been applied to a large number of these locomotives, but the last 500 thus far ordered are being equiped with a special type of hand-operated door, designed to swing inward. The air sanders used on the engines recently built and now under construction, are arranged to deliver sand in front of the leading and main drivers, and to the rear of the main drivers.



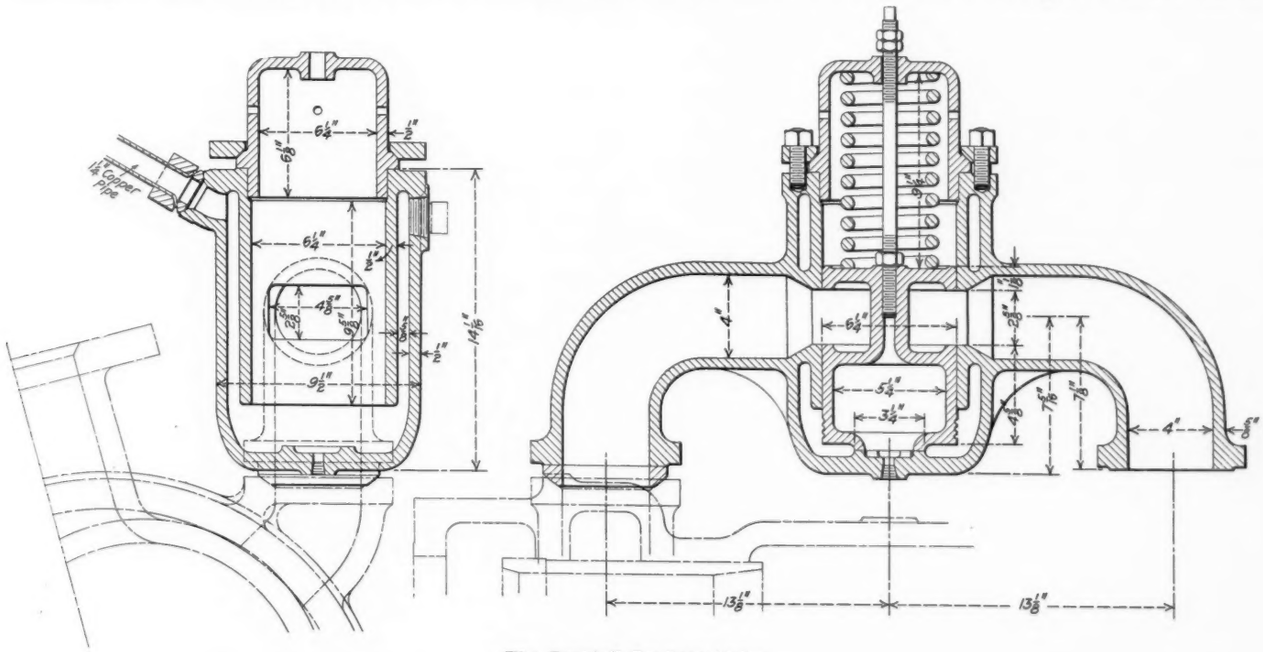
Variable Exhaust Pipe for the Russian Decapod Locomotives

Oil lubrication is applied to the crank pins and journals, and as the oil used is of a light quality, the journal boxes are provided with syphon wick feeds to prevent waste.

Owing to the severity of the climate, the cab, which is of steel, is lined with wood and is arranged so that it can be completely closed in at the sides. Special attention has been given to such details as steps and running boards. In accordance with Russian practice, the running boards are provided with outside hand rails.

The tender is mounted on two four-wheeled, arch-bar trucks. The tank is of the water-bottom type, and is equipped with a water level indicator. A radial buffer is applied between the engine and tender.

These locomotives, after being completely erected and tried under steam, are stripped; and each engine is shipped



The Zyabloff By-Pass Valve

in 34 packages. All the parts are boxed, with the exception of the boiler, driving-wheels, engine truck and tender wheels, and tender truck frames. The heaviest package, apart from the boiler, which weighs 56,450 lb., is the box containing the tender tank and various tender details. This box weighs 29,700 lb., and measures 25 ft. 4 in. by 10 ft. 4 in. by 8 ft. 3 in. The frame box, which contains one pair of frames complete, is also notable because of its size, as its measures 38 ft. 7 in. by 3 ft. 6 in. by 1 ft. 3 in., and weighs 17,200 lb.

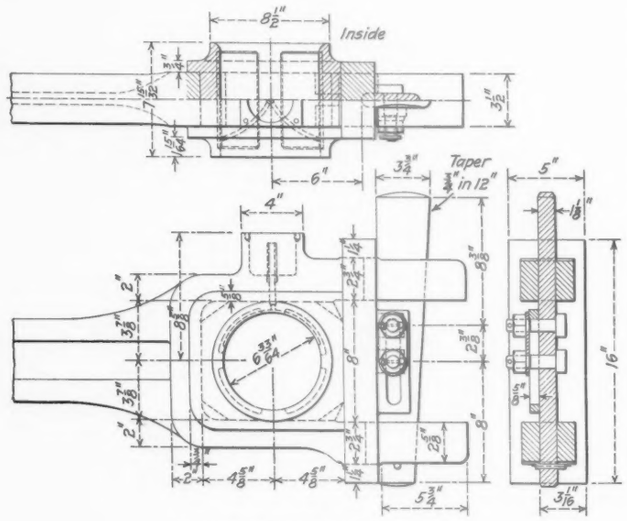
Further particulars of these locomotives are given in the table of dimensions:

General Data

Gage	5 ft.
Service	Freight
Fuel	Soft Coal
Weight in working order	201,000 lb.
Weight on drivers	176,500 lb.
Weight on leading truck	24,500 lb.
Weight of engine and tender in working order	(about) 333,400 lb.
Wheel base, driving	18 ft. 8 in.
Wheel base, total	27 ft. 10 in.
Wheelbase, engine and tender	60 ft. 3½ in.

Cylinders

Kind	Simple
Diameter and stroke	25 in. by 28 in.



Details of the Main Rod Stub

Valves

Kind	Piston
Diameter	12 in.

Wheels

Driving, diameter over tires	52 in.
Driving, diameter of center	1 m. 170 m.m.
Driving journals, main, diameter and length	10½ in. by 12 in.
Driving journals, others, diameter and length	8½ in. by 12 in.
Engine truck wheels, diameter	33 in.
Engine truck, journals	6 in. by 12 in.

Boiler

Style	Straight
Staying	Radial
Working pressure	180 lb. per sq. in.
Inside diameter of first ring	69 in.
Thickness of sheets	21/32 in.
Firebox, length and width	108 in. by 86¼ in.
Depth, front	76¼ in.
Depth, back	67¼ in.
Firebox plates, thickness, sides, back and crown	3/8 in.
Firebox plates, thickness, tube	5/8 in.
Firebox, water space	4 in.
Tubes, number and outside diameter	194—2 in.
Flues, number and outside diameter	28—5¾ in.
Tubes, length	17 ft.
Heating surface, tubes	2,383 sq. ft.
Heating surface, arch tubes	27 sq. ft.
Heating surface, firebox	200 sq. ft.
Heating surface, total	2,610 sq. ft.
Superheater heating surface (steam side)	579 sq. ft.
Grate area	64.6 sq. ft.

Tender

Wheels, diameter	36 in.
Journals, diameter and length	5½ in. by 10 in.
Water capacity	7,400 gal. (U. S.)
Coal capacity	8 metric tons

MODIFICATION OF FEDERAL LOCOMOTIVE INSPECTION RULES

As a result of a conference between representatives of the carriers, of the railway employees and of the chief inspector of the Locomotive Inspection Bureau of the Interstate Commerce Commission, an order was issued on September 20 by the I. C. C. giving modifications, for the period of the war, in certain of the rules and instructions for the inspection and testing of steam locomotives and tenders, to be effective at once and to continue in force during the period of the war, as follows:

"*Rule* 2—The lowest factor of safety for locomotive boilers which were in service or under construction prior to January 1, 1912, shall be 3.25.

"Effective six months after the close of the war the lowest factor of safety shall be 3.5.

"The dates on which factors of safety from 3.5 to 4, as provided in rule 2, become effective, shall be advanced for a period equivalent to the duration of the war.

"*Rule* 10: *Flues to be removed.*—All flues of boilers in service, except as otherwise provided, shall be removed at least once every four years, and a thorough examination shall be made of the entire interior of the boiler. After flues are taken out the inside of the boiler must have the scale removed and be thoroughly cleaned. This period for the removal of flues may be extended upon application if an investigation shows that conditions warrant it.

"*Rule* 16.—The date for removal of lagging for the purpose of inspecting the exterior of locomotive boilers as provided by rule 16, except where indication of leaks exist, shall be advanced for a period equivalent to the duration of the war.

"*Rule* 23.—*Method of testing flexible staybolts with caps.*—All flexible staybolts having caps over the outer ends shall have the caps removed at least once every two years and also whenever the United States inspector or the railroad company's inspector considers the removal desirable in order to thoroughly inspect the staybolts.

"The firebox sheets should be examined carefully at least once a month to detect any bulging or indications of broken staybolts. Each time a hydrostatic test is applied the hammer test required by rules 21 and 22 shall be made while the boiler is under hydrostatic pressure not less than the allowed working pressure, and proper notation of such test made on form No. 3.

"*Rule* 110.—*Time of cleaning.*—Distributing or control valves, reducing valves, triple valves, straight-air double-check valves, and dirt collectors shall be cleaned as often as conditions require to maintain them in a safe and suitable condition for service, but not less frequently than once each six months.

"*Add to Rule* 112.—On E. T. or similar equipment where the brake cylinder pressure is maintained regardless of piston travel the maximum piston travel for driving wheels brakes shall be 8 in.

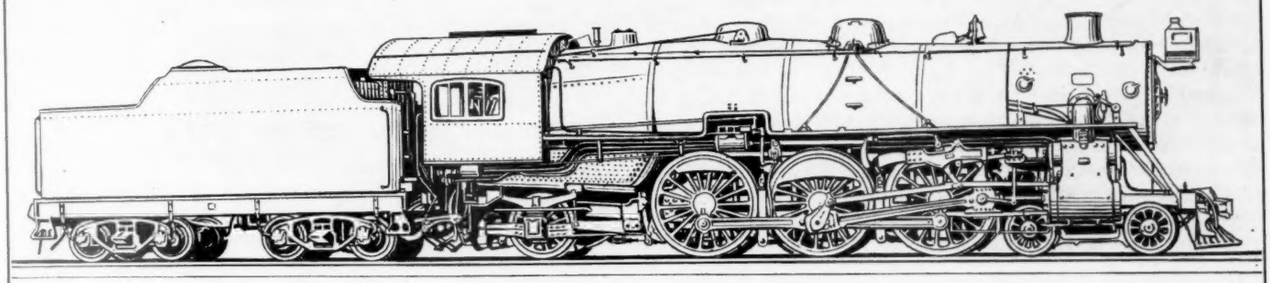
"*Rule* 128 (*d*).—*Locomotives in road service.*—The total amount of side motion of rods on crank pins shall not exceed ¼ in.

"*Locomotives in yard service.*—The total amount of side motion of rods on crank pins shall not exceed 5/16 in.

"*Rule* 142 (*c*).—Top leaf broken or leaves in top half or any three leaves in spring broken. (The long side of spring to be considered the top.)

"*Rule* 150 (*a*).—The minimum height of flange for driving and trailing wheel tires, measured from tread, shall be 1 in. for locomotives used in road service, except that on locomotives where construction will not permit the full height of flange on all drivers the minimum height of flange on one pair of driving wheels may be 5/8 in."

PRELIMINARY LOCOMOTIVE DESIGN



Methods Followed to Determine Size of Locomotives and the Fundamental Features of Their Design

BY W. R. MAURER
Mechanical Engineer, New York, New Haven & Hartford

AT times railway mechanical officers are asked to submit a specification of a locomotive that will haul between certain terminals a "limited" passenger train within a specified time; to estimate how many cars this engine will haul in a slower or express service, also the size train it will haul in local passenger service as well as in various kinds of freight service. The proposition sometimes takes a different form, in which the mechanical man is asked to determine the time required by a specific locomotive to haul a specific train between certain points.

Many of the published processes are slow and cumbersome, requiring a succession of tedious calculations. The writer has tried to evolve some quick methods with results which are reasonably correct and at the same time which are based on accepted formulae. Certain of the assumptions used in these methods are open to criticism, but as the results are quite accurate there should be no hesitancy in their use.

Before the work on problems of this kind is begun, a profile and alignment showing the grades, the length and degree of curves of the roadbed over which the trains are to be hauled, a clearance diagram, weight limitations, if any, and an operating time table showing the speed and similar restrictions should be provided.

For example, let us suppose that it is desired to know:

(a)—The size of locomotive capable of hauling a train consisting of 10 steel Pullman parlor equipment cars between terminals *A* and *B*, in three and a half hours, making three station stops each of three minutes duration.

(b)—The shortest time that a Pacific type locomotive with 26 in. by 28 in. cylinders, 79 in. wheels, and 200 lb. boiler pressure can make the run hauling the same train.

(c)—The time that will be required for the above Pacific type locomotive to haul between terminals *A* and *B* a train of 12 steel passenger equipment cars, the train to consist of one baggage, one mail, one express, one smoker, three coaches, one diner and four parlor cars.

(d)—The tonnage rating of the locomotive given in (b) when hauling a fast freight.

Problems (b), (c) and (d) admit of direct solution but (a) must be solved indirectly; that is by assuming the size of cylinder, driving wheels and steam pressure and then use the same procedure as in problem (b). In making these assumptions it will be found expedient to determine graphically the tractive effort, from low speeds to the maximum that the locomotive is to operate, for locomotives having different sizes of drivers, cylinders, strokes and pressures, and from this graph select the one that seems to give the best results at the average speed the train is to be hauled.

TRACTIVE EFFORT AT DIFFERENT SPEEDS

First calculate the tractive effort according to the formula

$$\frac{d^2 \times L \times 0.85 \times P}{D}$$

Where: d = Diameter of the cylinders in inches.
L = Length of stroke in inches.
P = Boiler pressure in pounds per square inch.
D = Diameter of driving wheels in inches.

This gives the maximum tractive effort.

The tractive effort of a locomotive diminishes as the speed increases. An accepted method by which these decreases may be determined has been published by the American Locomotive Company in its Bulletin 1017. The maximum tractive effort is multiplied by a "speed factor" (see Table I) corresponding to the piston speed in feet per minute, to obtain the tractive effort at the speed in miles per hour at which the specific piston speed obtains. For convenience Table II is given here, which shows the piston speed at 10 m.p.h. for various lengths of stroke and diameter of drivers. For higher train speeds, increase the piston speeds accordingly.

The tractive effort at 10, 20, 30, 40, 50, 60 and 70 m.p.h. is found by multiplying the maximum tractive effort by the speed factors. By plotting these tractive efforts on cross section paper, the tractive efforts at any speed can be determined. By drawing on one chart the tractive efforts of several different locomotives, the advantages of one locomotive over another can be readily seen.

At slow speeds, the longer the stroke or smaller the driver, the greater the tractive effort, but as the speeds increase this ceases to be true and at high speeds and within reasonable limits the locomotive with large drivers and short stroke produces the largest tractive effort.

TRAIN RESISTANCE

All of the power of the locomotive is utilized in overcoming the resistance of itself and of the cars hauled. This resistance may be divided into six items as follows:

(a)—Engine friction or energy required to overcome the friction of the driving wheels, piston, valves, etc., is equal to the product of the weight on drivers in tons multiplied by 22.2 lb.

(b)—Grade resistance is equal to 20 lb. per ton multi-

plied by the grade in per cent. If the grade is expressed in feet use Table III.

(c)—Curve resistance is equal to 0.8 lb. per ton per degree of curvature or, roughly, is equal to increasing the grade in feet per mile by 2 ft. for each degree of curvature.

(d)—Resistance of the engine trucks, trailing wheels and tenders is assumed to be the same as on the cars in the train.

(e)—Car resistance for passenger cars may be obtained from Fig. 1; for freight cars from Fig. 2.

(f)—Head air resistance is equal to 0.24 multiplied by the square of the velocity in miles per hour.

The sum of these six items may be considered as the total resistance to be overcome, and can be safely used for summer conditions and good track. Cold weather, high winds and poor track will increase the resistance quite materially. (a), (b), (d) and (f) resistances are taken from the American Locomotive Company's Bulletin 1001. Grade resistance (b) is susceptible of accurate computation, being the ratio of the distance the train is raised to the distance traveled. It may be either positive or negative depending upon whether the grade is ascending or descending. If descending then this resistance is to be either deducted from the total resistance or the available tractive effort is to be increased by this amount.

The passenger car resistance is taken from a paper by Prof. E. C. Schmidt and H. H. Dunn, an abstract of which was published in May, 1917, issue of the *Railway Mechanical Engineer* on page 247. The freight car resistance is taken from Bulletin 43 of the University of Illinois, being a report of an investigation by Prof. E. C. Schmidt.

Acceleration.—In getting a train up to speed, the increasing resistance due to speed and the diminishing power of the locomotive prevent a uniform rate of acceleration, a higher rate of acceleration being obtained at the starting, which is gradually reduced as the train gets under way. It requires about 100 lb. to accelerate or retard a ton of weight at the rate of one mile per hour per second. For passenger trains an average rate of acceleration and retardation due to grade can be assumed as 0.2 m.p.h. per sec., while the retarding effect on a train equipped with high speed brakes can be assumed at two m.p.h. per sec. Fig. 3 shows the distance traveled and time consumed in accelerating or retarding at a rate of 0.2 m.p.h. per sec. This acceleration curve is also used to determine the time required to accelerate passenger trains under ordinary conditions. Fig. 4 shows similar information at a rate of 2 m.p.h. per sec. The abscissas represent the distances and seconds of time, while the ordinates represent the speed at each point. To determine the time required to accelerate from zero to 40 m.p.h., the vertical line passing through the point where 40 m.p.h. line intersects the curve is marked 200 seconds. At the bottom is shown that the distance traveled is 1⅛ miles. In the same manner the time consumed and distance traveled from any speed to any other speed can readily be determined.

The distance required to make a stop from any speed by means of the emergency brakes is similarly found from Fig. 4. "Service" stops or slow-downs are made at a slower rate; approximately one mile per hour per second. This rate

Table I—Speed Factors

The tractive power of a locomotive decreases as the piston speed increases. For piston speeds over 250 ft. per minute, multiply the maximum tractive power by the factor corresponding to the piston speed given below:

Piston speed. Up to	Speed factor		Piston speed.	Speed factor	
	Saturate	Superheat		Saturate	Superheat
250	1.000	1.000	940	.441	.472
260	.991	.991	960	.432	.463
280	.972	.972	980	.422	.454
300	.954	.954	1,000	.412	.445
320	.935	.935	1,020	.404	.437
340	.917	.917	1,040	.396	.429
360	.899	.899	1,060	.388	.421
380	.881	.881	1,080	.380	.413
400	.863	.863	1,100	.372	.405
420	.844	.844	1,120	.365	.398
440	.826	.826	1,140	.358	.391
460	.808	.808	1,160	.351	.385
480	.790	.790	1,180	.344	.378
500	.772	.772	1,200	.337	.371
520	.754	.754	1,220	.331	.365
540	.735	.736	1,240	.325	.359
560	.717	.718	1,260	.319	.353
580	.698	.700	1,280	.313	.347
600	.680	.682	1,300	.307	.342
620	.662	.667	1,320	.302	.337
640	.644	.651	1,340	.297	.332
660	.626	.636	1,360	.293	.327
680	.608	.620	1,380	.288	.322
700	.590	.605	1,400	.283	.318
720	.575	.593	1,420	.278	.314
740	.561	.581	1,440	.274	.310
760	.546	.568	1,460	.270	.306
780	.532	.555	1,480	.265	.302
800	.517	.542	1,500	.261	.297
820	.505	.532	1,520	.257	.293
840	.494	.522	1,540	.253	.289
860	.483	.511	1,560	.249	.285
880	.471	.500	1,580	.245	.281
900	.460	.490	1,600	.241	.278
920	.450	.481			

Table II—Piston Speed in Feet per Minute at 10 M. P. H.

Driver Diameters	Stroke in Inches				
	24 in.	26 in.	28 in.	30 in.	32 in.
50 in.	268.9	291.2	313.7	336.0	358.5
51 in.	263.6	285.6	307.5	329.5	351.4
56 in.	240.1	260.1	280.1	300.1	320.1
57 in.	235.9	255.5	275.1	294.8	314.5
62 in.	217.0	235.0	253.0	271.0	289.2
63 in.	213.4	231.1	248.9	266.7	284.5
68 in.	197.7	214.2	230.7	247.1	263.6
69 in.	194.8	211.0	227.2	243.5	259.7
72 in.	186.7	202.3	217.8	233.4	249.0
73 in.	184.1	199.5	214.8	230.2	245.5
76 in.	176.9	191.6	206.2	221.0	235.8
77 in.	174.6	189.1	203.7	218.0	232.8
78 in.	172.3	186.6	201.0	215.4	229.7
79 in.	170.2	184.4	198.6	212.7	226.9
80 in.	168.1	182.1	196.1	210.1	224.1

Table III—Resistance in Pounds per Ton Due to Grade

Resistance per ton is equal to 0.3788 lb. multiplied by the grade in feet per mile.

Grade (in ft.)	Resistance (lb.)	Grade (in ft.)	Resistance (lb.)	Grade (in ft.)	Resistance (lb.)
1	.379	21	7.955	41	15.531
2	.758	22	8.334	42	15.910
3	1.136	23	8.712	43	16.288
4	1.515	24	9.091	44	16.667
5	1.894	25	9.470	45	17 046
6	2.273	26	9.849	46	17.425
7	2.652	27	10.228	47	17.804
8	3.030	28	10.606	48	18.182
9	3.409	29	10.985	49	18.561
10	3.788	30	11.364	50	18.940
11	4.167	31	11.743	51	19.319
12	4.546	32	12.122	52	19.698
13	4.924	33	12.500	53	20.076
14	5.303	34	12.879	54	20.455
15	5.682	35	13.258	55	20.834
16	6.061	36	13.637	56	21.218
17	6.440	37	14.016	57	21.592
18	6.818	38	14.394	58	21.970
19	7.197	39	14.773	59	22.349
20	7.576	40	15.152	60	22.728

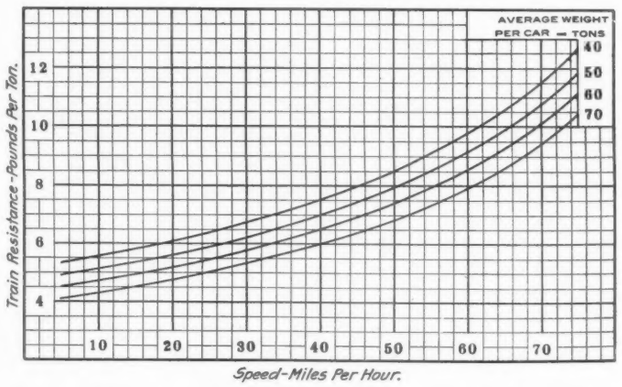


Fig. 1—Speed Resistance for Passenger Equipment Cars of Various Average Weights

requires twice the time and twice the distance to produce the results obtained at the two m.p.h. rate. All of the above curves are assumed as meeting the average conditions.

If more exact results are required it will be necessary to lay out curves for all rates of acceleration and to calculate the effects of the brakes from the braking condition on the cars, the kind of brake shoes, etc. A very complete discussion on Brake Performance* is given in a paper by S. W.

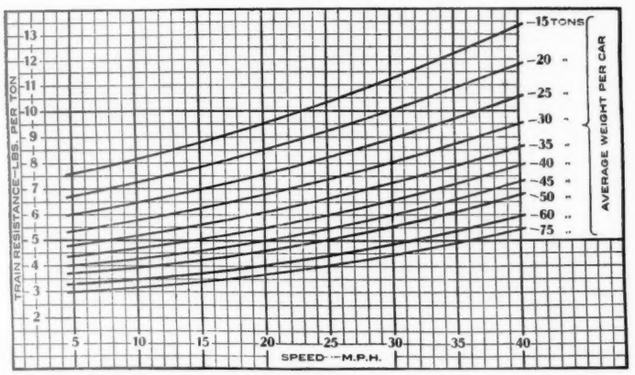


Fig. 2—Speed Resistance for Freight Cars of Various Average Weights

Dudley at the February, 1914, meeting of the American Society of Mechanical Engineers. Also see "Locomotive Operation" by G. R. Henderson.

It is to be remembered that to accelerate at a speed of 0.2 m.p.h. per sec. requires 20 lb. of tractive effort per ton of train, while the 0.1 rate requires half that amount.

Weather Conditions.—Cold weather decreases the tractive effort by decreasing the efficiency of the boiler as well as increasing the machine friction. Probably 5 per cent is ample to cover both. But the effect on car resistance is considerably higher. Prof. Schmidt in a paper before the Central Railway Club called attention to the fact that the cold had no effect on grade, curve, or acceleration resistance, but only affects the resistance on a straight level track at uniform speed. Therefore, the percentage reduction should not be as high on heavy grades as on low grades.

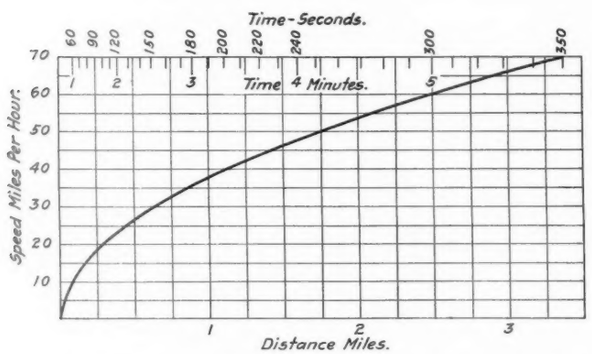


Fig. 3—Speed—Time—Distance Curve for an Acceleration Rate of 0.2 M. P. H. per Sec.

SPEED-TIME DETERMINATIONS

With a thorough understanding of the fundamentals given above, a curve can be drawn to show the maximum speeds for any locomotive hauling a given train over any piece of track. For example, consider the 26 in. by 28 in. Pacific locomotive with the 10 parlor cars mentioned above in problem (b). The following data is necessary for the determinations:

Tractive effort	40,800 lb.
Weight on locomotive drivers	83 tons
Weight of locomotive and tender	209 tons
Weight of trailing load	744 tons
Weight of total train	953 tons

By means of Tables I and II plot the tractive efforts from 10 to 70 m.p.h. in 10 mile increments (see Fig. 5). Then by means of the data given in paragraphs (a), (d), (e) and (f) determine the engine friction, car resistance (including the weight of the tender, engine truck and trailing truck) and head air resistance for the same speeds and subtract them from the tractive effort curve (Fig. 5), giving the tractive effort available for resistance due to grade (including curvature) and acceleration.

With this as a base every portion of the line should be studied to determine the time it will take for the train to pass

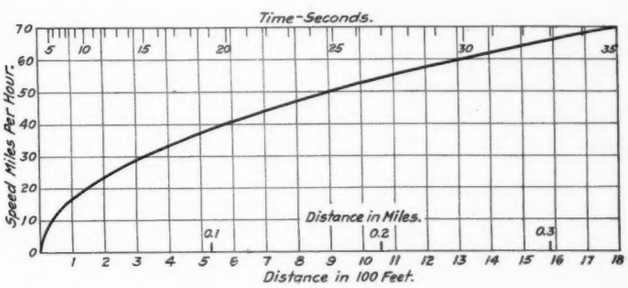


Fig. 4—Speed—Time—Distance Curve for an Acceleration Rate of 2. M. P. H. per Sec.

over it and the speed that may be attained throughout the different sections. Assuming that 60 m.p.h. is the limiting speed it will take 5 min. and 2½ miles to accelerate to that speed (see Fig. 3). Assuming further that from that point there is a 10 mile stretch of straight track, at the end of which there is a one per cent grade 5 miles long with 5 deg. curves, it will take 10 minutes to cover the straight track and the

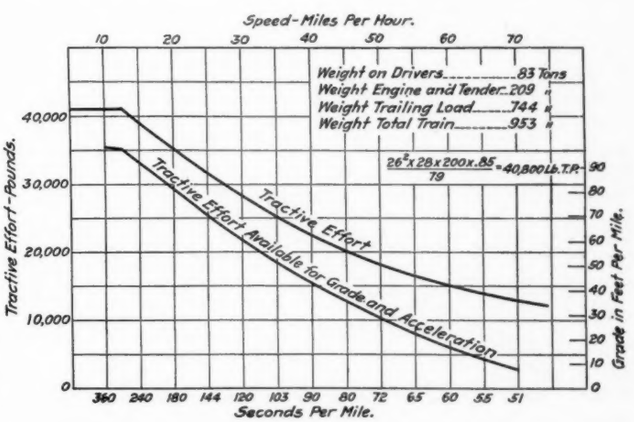

Speed-Miles Per Hour.
Weight on Drivers 83 Tons
Weight Engine and Tender 209
Weight Trailing Load 744
Weight Total Train 953
Tractive Effort-Pounds.
Tractive Effort
Tractive Effort Available for Grade and Acceleration
Grade in Feet Per Mile.
Seconds Per Mile.

Fig. 5—Tractive Effort Diagram for Determining Maximum Speed at Which the Locomotive Can Operate

train will strike the grade at the rate of 60 m.p.h. The grade will require—

$$953 \times 20 = 19{,}060 \text{ lb.}$$

additional tractive effort and the curve will require—

$$953 \times 0.8 \times 5 = 3{,}812 \text{ lb.}$$

or a sum total of 22,872 lb. of tractive effort. This additional load will slow the train down to 38 m.p.h. (see Fig. 5), which will take 1 min. 50 sec., and distance traveled during that time will be 1½ miles (see Fig. 3). The remain-

*An abstract of this paper was published in the *Railway Age Gazette, Mechanical Edition*, of March, 1914, on page 136.

ing 4½ miles will be traveled at the rate of 38 m.p.h. or at the "balanced speed" and will be covered in—

$$\frac{4.5 \times 38}{60} = 2 \text{ min. } 51 \text{ sec.}$$

Thus it has taken the train—

$$5 + 10 + 1{:}50 + 2{:}51 = 19 \text{ min. } 41 \text{ sec.}$$

to cover the 17½ miles to the top of the hill.

Exactly the same procedure is followed throughout the rest of the speed determinations, using Fig. 4 for determining time of retardation for the emergency application of the brakes and one-half these times for the service applications as explained above. For slow passenger or freight trains, acceleration or retardation values one-half of those shown in Fig. 3 should be used. When the entire division over which the locomotive with its train is to operate is thus analyzed the total time it will take to run the train over the division will be obtained and the speeds at the various parts of the division will be determined. This will give the *least* time required to make the run. In designing a locomotive for a specific train, liberal allowances should be made for slow orders, signals, etc., so that the locomotive will have sufficient reserve capacity to make up a reasonable amount of lost time.

DESIGNING THE LOCOMOTIVE

Let it be supposed that the locomotive to be designed is of the Pacific type, which has the following characteristics: Simple cylinders, 26 in. by 28 in.; drivers, 79 in.; boiler pressure, 200 lb. superheated steam; tractive effort, 40,800 lb.

Weight:—The weight on drivers should range from 4 to 4¼ times the tractive effort, which would be from 163,200 to 173,400 lb. on the drivers. The weight on drivers of a Pacific type locomotive is about 65 per cent of its total weight. Then the total weight would be between 252,000 and 267,000 lb. As the locomotive is to have a high steam factor the probable weight will be 267,000 lb., the balance of 93,600 lb. being equally distributed between the engine and trailer trucks. By moving the pins in the spring rigging the distribution may be changed somewhat.

Before proceeding too far a wheel spacing and load diagram should be submitted to the bridge engineer to determine whether or not the bridges will stand the proposed loading. Some bridge engineers have all the bridges on the line calculated in terms of some unit, such as Coopers E60. Then by computing the load diagrams of the proposed locomotive in the same terms, it can readily be ascertained if the proposed locomotive will produce stresses (moments and shears) that are above the safe limit. It was found that by changing the distribution of the loads to 50,000 lb. on engine truck and same on the trailer and 55,000 lb. on each of the drivers the bridge stresses would not be excessive, a variation of one to two per cent being allowed.

Boiler and Cylinders.—In locomotive design the two important elements are the boiler and cylinders, the work of the latter being dependent upon the former. It has been stated that the boiler capacity for a locomotive cannot be made too large, but when the weight of the locomotive is limited, then the importance of properly proportioning the boiler to the work it has to do is quite vital. In American Locomotive Company's Bulletin 1017, Mr. Cole gives some valuable data on boiler proportions upon which the following suggestions are based, the fundamental principle being that the boiler horsepower should about equal the cylinder horsepower.

The cylinder horsepower is computed from the formulae:

HP = .0212 PA for saturated steam.
HP = .0229 PA for superheated steam.
In which A = Area in square inches of one cylinder.
P = Boiler pressure.

It is assumed that 27 lb. of saturated steam are consumed per horsepower hour, while for superheated steam 20.8 lb. are used.

The cylinder horsepower of a 26 in. diameter cylinder simple locomotive at 200 lb. boiler pressure is 2,434 and if superheated steam is used the steam consumption is $2{,}434 \times 20.8 = 50{,}627$ lb. Then the boiler must be capable of evaporating approximately 50,600 lb. of water per hour, provided the locomotive will not exceed the weight limitations. The grate area required is determined by dividing the horsepower by 30 for saturated steam or by 36.9 for superheated steam. The above locomotive, therefore, should have $2{,}434 \div 36.9 = 66$ sq. ft. of grate, although 60 sq. ft. will answer if a high grade of coal is used.

The determination of the number of tubes required is more or less complicated in so far as the amount of water evaporated per square foot is concerned. Short tubes are more efficient than long ones but not so economical on coal. The A. L. Co.'s bulletin 1017 gives a table of evaporative values of tubes and flues of varying diameters, lengths and spacing. As the tube spacing most often used is ¾ in. (that is the space between the tubes proper, not the bridges) and the spacing of superheated flues is generally 1 in., Fig. 6 has been prepared to show the pounds of water evaporated by tubes and flues of various lengths. It will be found that while more 2 in. tubes than 2¼ in. can be applied, thus providing more heating surface, the greater efficiency of the 2¼ in. tubes will more than make up this difference. It

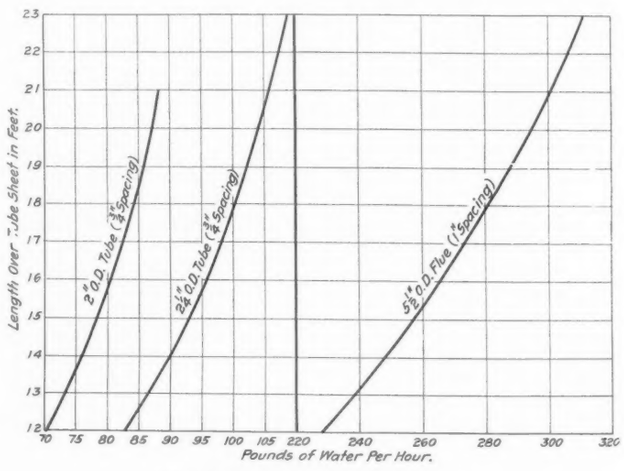


Fig. 6—Tube Evaporation Curves

will be noticed that the evaporation curves straighten as the lengths increase. It follows that the longer the boiler, the more it will weigh, not only on account of more metal but on account of the water as well.

Now the evaporation value of a square foot of fire box heating surface, including that of arch tubes and combustion chambers, is taken as 55 lb., which is at least five times that of a square foot of tube or flue surface. Therefore where the construction would require flues 20 ft. long or over without the use of a combustion chamber, by introducing a combustion chamber the tubes and flues can be shorter, the boiler horsepower will be materially increased while at the same time the weight of the boiler will be reduced.

The writer does not know the methods used by the Locomotive Superheater Company for determining the number of superheater units. It is, therefore, best to get their recommendation first. If time is limited the number may be taken from the published descriptions of similar locomotives. For the Pacific type locomotive which we are studying, let us assume that there are to be 36 5½-in. flues, and that flues and tubes are to be 18 ft. long, the combustion chamber to be 3 ft., 6 in. long and 56 in. in diameter. This would give

a combined heating surface for the firebox, combustion chamber and arch tubes of 320 sq. ft., which multiplied by 55 lb. would give 17,600 lb.; deducting this from 50,600 lb. leaves 33,000 lb. to be evaporated by the tubes and flues. One 18-ft. 5½-in. flue (17 ft., 11 in. between heads) evaporates 280 lb. of steam per hour. The 36 flues will evaporate 10,080 lb., which leaves 22,920 lb. to be evaporated by the tubes. From Fig. 6 we find that one 2¼-in. tube, 18 ft. long, evaporates 100 lb. of steam per hour. Thus 229 tubes will give the remaining 22,900 lb. of steam and provide a 100 per cent boiler.

Good boiler design requires that the clearance between the

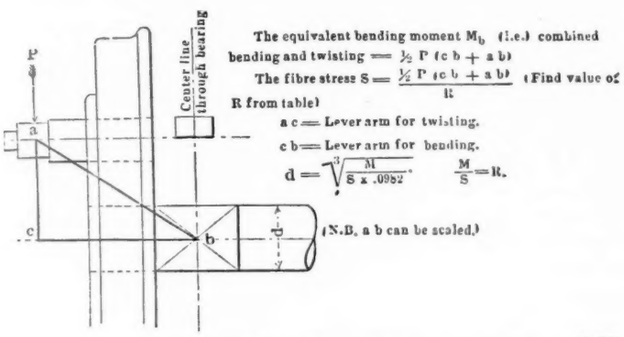

P
Center line through bearing
a
c
b
The equivalent bending moment M_b (i.e.) combined bending and twisting = ½ P (c b + a b)
The fibre stress S = ½ P (c b + a b) / R (Find value of R from table)
a c = Lever arm for twisting.
c b = Lever arm for bending.
$d = \sqrt[3]{\frac{M}{S \times .0982}}$ $\frac{M}{S} = R.$
(N.B. a b can be scaled.)

Fig. 7—Method of Calculating Driving Axles

shell and tubes shall not be less than 1¼ in. at the front tube sheet, and 1½ in. at the top, 1 in. at the sides, and 2 in. at the bottom at the back tube sheet. The 5½-in. flues should be spaced on 6½ in. centers and the 2¼-in. tubes should be spaced on 3 in. centers. A tube and flue layout for the front and back tube sheets should be made on tracing cloth and by superimposing the two layouts it will be easy to discover if a better scheme can be provided. After a careful study it is not unusual to increase the number of tubes a dozen or so. The distance from the crown to the roof of the boiler should be not less than 25 per cent of the outside

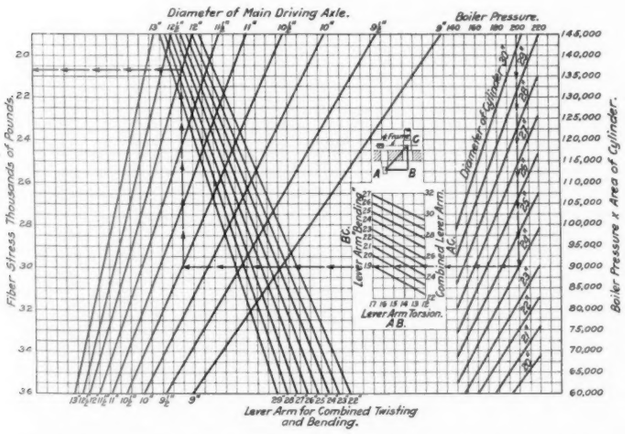

Diameter of Main Driving Axle.
Boiler Pressure.
Fiber Stress Thousands of Pounds.
Boiler Pressure x Area of Cylinder.
Diameter of Cylinder.
Lever Arm for Combined Twisting and Bending.
Lever Arm Bending B C.
Combined Lever Arm A C.
Lever Arm Torsion. A B.

Fig. 8—Diagram for Determining the Fibre Stress for Any Given Driving Axle Diameter

diameter of the largest boiler course. From the foregoing it will be found that the outside diameter of the first course would be 78 in. and the diameter for the back course 88 in.

The boiler should be built with a factor of safety of not less than 4½. For a 200 lb. pressure boiler, a rough rule for estimating purposes is that with a sextuple seam the thickness of the shell is 1 per cent of the boiler diameter; of a dectuple seam 0.9 per cent; of a diamond seam 0.88 per cent. The throat sheet should be not less than 24 in. deep in order to provide for a fairly thick fire over the grates.

As shown in the May, 1917, issue* of this journal, the efficiency of the boiler and the drawbar horsepower are greatly increased by the use of a brick arch. In designing the ash pan, the openings for the admission of air should be as near 15 per cent of the grate area as the construction will permit.

Frames.—While it is the common practice to use the same factors in designing Vanadium cast steel frames as is used for ordinary open hearth cast steel frames, the practice would seem faulty, as a material having a higher yield point should be stressed higher, thus deriving a benefit from the higher priced material. The writer has used the following with success in determining the sectional area at different points of frame:

	O. H. Steel	Vanadium
Top of pedestal	T × .0038	T × .0035
Top rail between pedestals	T × .0033	T × .0030
Lower rail between pedestals	T × .0022	T × .0020

In which T = piston thrust of one cylinder.

Axles.—Axle bearing pressures in pounds per square inch should not exceed the following limits:

	Passenger	Freight
Driving	175 lb.	200 lb.
Traveling	175 lb.	185 lb.
Engine truck	160 lb.	180 lb.

Driving axles are subjected to a variety of strains. The journals must be large enough to prevent undue heating and the diameters must be such that the fibre stresses, produced not only by the superimposed load but also by the torsional stresses caused by the pressure on the crank pin, must be well within the elastic limits of the material. The method for calculating the size of the axle is shown in Fig. 7.

In a paper on "Alloy Steel in Locomotive Design" read at the 1916 convention of the American Railway Master

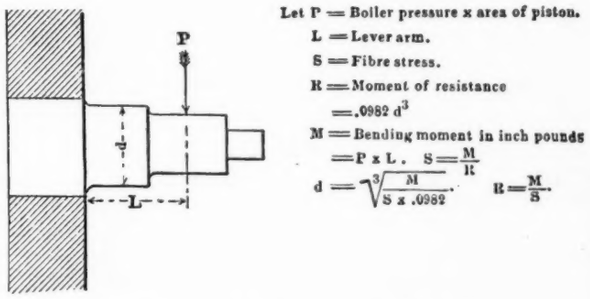

P
L
Let P = Boiler pressure x area of piston.
L = Lever arm.
S = Fibre stress.
R = Moment of resistance = .0982 d^3
M = Bending moment in inch pounds = P x L. $S = \frac{M}{R}$
$d = \sqrt[3]{\frac{M}{S \times .0982}}$ $R = \frac{M}{S}$.

Fig. 9—Method of Calculating Crank Pins

Mechanics Association (see also *Railway Mechanical Engineer* for April, 1916, page 171, and Daily Railway Age Gazette for June 21, 1916, page 1499) by L. R. Pomeroy, a diagram (Fig. 8) for quickly determining fibre stresses and sizes for driving axles is given, this diagram being based on the generally accepted formulae shown in Fig. 7. The method of reading the diagram (Fig. 8) for main rods is indicated by the dotted lines. From the boiler pressure, found at the top, read down to the diagonal for the cylinder diameter, at the right of this intersection read the piston thrust or load on the pin, thence to the left to the lever arm *A C* (the diagonal distance between the center of driving box and main rod fit on crank pin), thence upward to the diameter, thence to the left find the fibre stress. In the same manner the fibre stresses in the other driving axles may be found, assuming that the thrust on the crank pin is 40 per cent of the weight on all the drivers actuated by the pin or assume some arbitrary percentage of the piston thrust.

To determine the crank pin stresses use Fig. 9.

Fibre stresses in driving axles made of open hearth steel having an ultimate tensile strength of 80,000 lb. and an

*Locomotive Brick Arch Tests—page 235.

elastic limit of about 40,000 lb. should not exceed 21,000 lb. per sq. in., while for crank pins the limit should be 15,000 lb. Should alloy steel with a higher elastic limit be used then the fibre stresses may be increased proportionately.

By hollow boring, the weight of driving axles and crank pins may be greatly reduced, without materially decreasing their strength. A 4-in. hole in a 12-in. axle reduces the weight 11 per cent, while its strength is reduced only slightly over 1 per cent. A 4-in. hole in a 9-in. axle reduces the weight 20 per cent, while its strength is reduced less than 4 per cent. Certainly an efficacious method of saving weight but at an increased cost.

Miscellaneous.—The question of correct balance is all important and closely allied with it is the question of the weight of the reciprocating parts. This weight may be reduced by the use of alloy steel. The formulae for determining the proper counterbalance may be found in the 1915 proceedings of the Master Mechanics' Association. Similar formulae are found in the Master Mechanics' proceedings for designing main and side rods. Care should be taken to avoid offsets in these members as well as in all motion work. The wheels should be located to provide sufficient clearance space between them and other parts of the locomotive.

The problem of determining the estimated weight of the locomotive and its distribution is difficult when the complete file of the weights of locomotive parts is not at hand. Probably the easiest way to determine this is to compare the proposed locomotive with another of the same type and for which drawings and weight distributions are available, listing the differences in weight in "plus" and "minus" columns and in this way a fair estimate will be obtained. To determine with any degree of accuracy the distribution of weight on drivers and trucks, the center of gravity of the boiler and principal parts should be determined and their effect on the total weight distribution he calculated.

The capacity of the tender should be such as to meet the demands of the service in which the locomotive is to be used. The distance from the coal gate to the firedoor should be not less than 6 ft. or more than 6 ft. 6 in., and where there is no coal pusher the slope sheets should come within 14 in. of the coal gates and have an angle of 37 deg., so that the coal will feed to the coal gate without it being necessary to shovel it ahead. If the wheel base of the locomotive and tender has been determined, the longitudinal center of gravity should be found. Twice the distance from the center of gravity to the furthest wheel plus about 18 in. will be the diameter of the smallest turntable on which the locomotive can be turned.

No attempt has been made to go into the design of the locomotive in any great detail, as the limits of space forbid, but with the above, one should be able to make a reasonably accurate preliminary design of the locomotive, which, of course, is necessary before any definite arrangements are made. With the preliminary design determined upon, a finished locomotive may be designed by the use of good engineering practice.

FIREBOX TEMPERATURE EXPERIMENTS

Oil Burning Locomotive Tests Show Increases in Temperatures and Boiler Efficiency with Gaines Wall

FIREBOX temperatures—and particularly temperatures at different points in the firebox—is a subject of more than passing interest to railway mechanical officers; but, unfortunately, it is a subject about which little is known. The high-temperature thermocouples in use at the present time are impractical for road test purposes, so firebox temperature determinations have been confined to a few test plants, such as the Pennsylvania Railroad's Altoona plant, Purdue University and the University of Illinois. At these plants firebox temperatures have been determined in numerous tests, but the temperatures were determined at only one point, that generally being at the rear of the brick arch.

The Texas & Pacific recently had occasion to take firebox temperature readings at different points in the fire box, and some interesting data was obtained during the tests. The locomotives tested were of the 2-10-2 type, in oil-burning service, the size and design being indicated by the following data:

Gage	4 ft. 8½ in.
Service	Freight
Fuel	Oil
Tractive effort	62,700 lb.
Weight in working order	324,600 lb.
Weight on drivers	262,100 lb.
Weight on leading truck	27,100 lb.
Weight on trailing truck	35,400 lb.
Weight of engine and tender in working order	501,300 lb.
Cylinders, diameter and stroke	28 in. and 32 in.
Driving wheels, diameter over tires	63 in.
Working pressure	185 lb. per sq. in.
Boiler, outside diameter of first ring	84 in.
Firebox, length and width	176½ in. by 82 in.
Firebox type	Jacobs-Shupert
Tubes, number and outside diameter	267—2 in.
Flues, number and outside diameter	41—5¾ in.
Tubes and flues, length	18 ft.
Heating surface, tubes and flues	3,539 sq. ft.
Heating surface, firebox	307 sq. ft.
Heating surface, total	3,846 sq. ft.
Superheater heating surface	886 sq. ft.
Grate area	70 sq. ft.

FIREBOX TEMPERATURES.

The locomotive was equipped with a firebox of the Jacobs-Shupert type, 176½ in. long, there being a 42½ in. combustion chamber at the front end, separated from the main portion of the firebox by a Gaines wall with five 3-in. air ducts. The object of the tests was to ascertain the firebox temperatures at different points, in order to determine if there was any concentration or localization of temperatures above the Gaines wall or in the combustion chamber. Two series of tests were run—one with the Gaines wall in place and one with the wall removed.

Fig. 1 shows the general firebox layout, the wall being shown in dotted lines and the pyrometer locations being shown by small circles. Locations *A*, *B*, *C* and *D* show points at which temperature determinations were made with the wall in place, while *A'*, *B'*, *C'* and *D'* show locations of thermo couple with the wall removed. It is the usual practice to insert thermocouples in firebox by cutting a hole through the side sheets and placing a thimble therein to accommodate the thermocouple; but as this was not desirable in the present tests, the thermocouples were introduced into the firebox through holes in the combustion chamber floor and fire pan, the body of the thermocouple being protected from the flame by a water jacket.

Temperatures at the different points were obtained by the use of a Platinum Rhodium Thermocouple, used with a Leeds & Northrup potentometer indicator. The instrument was furnished by the railway department of the University

of Illinois and the readings were taken by Professor J. M. Snodgrass, of that institution. As the type of instrument used is not of a sufficiently rugged character to withstand the jars and shocks of a road test, standing tests were conducted by removing the main valves and blowing all the steam generated through the valve chamber and out of the stack.

Four tests were run with the wall in place and four with the wall removed; and in order to make them strictly comparable, an endeavor was made to keep the oil fired during each test the same, by working the firing valve and the throttle in constant position. As the results show, however, this did not accomplish the desired effect, as a little more oil was burned without the wall than with it. A Louisiana fuel oil with a gravity of 24 to 30 and heat value of 19,332 B. T. U. per pound was used. The temperatures obtained during the tests are shown in Table I.

As a check on the temperatures obtained with the Leeds & Northrup pyrometer, a radiation pyrometer was used, this

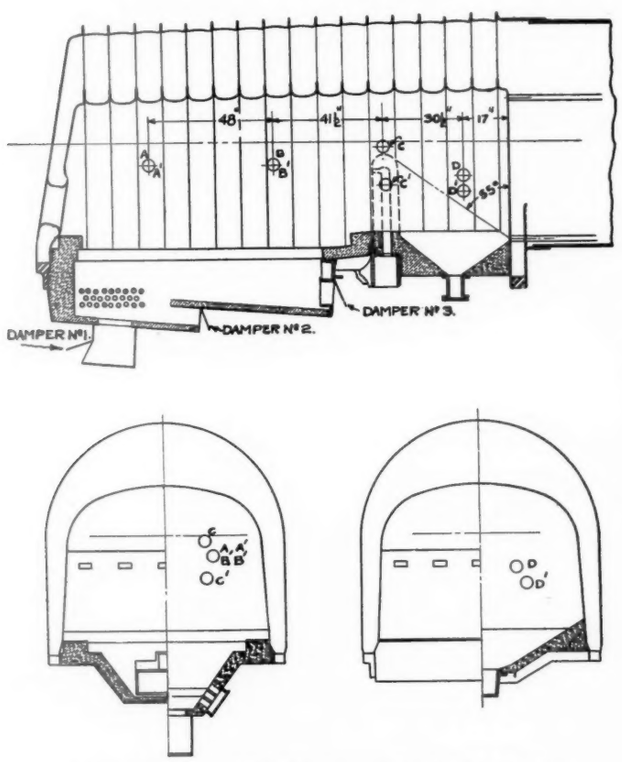


Fig. 1—Location of the Thermocouples in the Firebox.

being inserted through the sand hole in the firedoor. The temperatures registered by this instrument were nearly constant throughout the range of tests. In order to compare the standing test conditions with road service, two road tests were made, during which temperatures were obtained with the radiation pyrometer inserted through the door. The results of this test are also shown in Table I.

Fig. 2 shows graphically the maximum temperature ranges, with and without the Gaines wall, the average temperatures being 20 to 60 deg. lower than those indicated by the curves. It will be observed that with the wall in place, the highest temperatures were obtained in the back part of the firebox; and that there was a gradual drop in temperatures as the flames approached the flue sheet. With the wall removed, the temperatures in the rear and middle portions of the firebox were fairly uniform, with a decided drop in the combustion chamber space. At a point directly above the Gaines wall location, the temperatures were higher with the wall removed than when the wall was in place, this being due to the fact that the wall has the effect of baffling the flames and throwing them back into the rear portion of the firebox where combustion is most intense; whereas with wall removed there was no such baffling effect and there was a noticeable short-circuiting of the flames from the burner over into the combustion chamber.

The temperatures shown are probably lower than might be expected in burning fuel oil under these conditions, but this can be accounted for in two ways:

First: The large volume of the firebox (433 cu. ft.)

TABLE I—AVERAGE TEMPERATURE AND DRAFT
STANDING TEST—ENGINE 511

Test No.	L. & N. Pyrometer Location	Firebox Temperature F° L. & N. Pyrometer Avg.	L. & N. Pyrometer Max.	Radiation Pyrometer Through Door	Front End Temp. F°	Draft Ins. of Water Fire Pan	Draft Ins. of Water Front End	Pounds Oil Burned Per Hour
3	A	2,315	2,330	.....	595	3.8	8.4	3,952
7	A'	2,000	2,040	2,000	645	4.1	8.9	4,164
2	B	2,050	2,140	2,045	...	3.0	7.8	4,004
6	B'	1,940	2,055	2,040	615	3.8	8.5	4,008
1	C	1,855	1,875	2,315	...	2.9	8.0	3,139
8	C'	1,960	2,020	2,015	625	3.9	8.3	4,261
4	D	1,580	1,645	2,025	590	3.8	8.5	3,607
5	D'	1,710	1,730	2,030	580	3.7	8.0	4,135

ROAD TEST—ENGINES 500 AND 511

Engine 511, with Gaines Wall...	2,110	570	3.3	6.9	*2,157
Engine 500, without Gaines Wall	2,175	600	4.1	7.3	*2,982

Pyrometer Locations A, B, C and D are with Gaines Wall.
Pyrometer Locations A', B', C' and D' are without Gaines Wall.

*Pounds of oil burned on trip Longview to Marshall, Tex.

reduces the heat liberation per unit of volume and therefore reduces the temperature. If the same amount of oil were burned in a firebox of smaller dimensions, the heat liberation per cubic foot of volume would be greater and the temperatures would be higher.

Second: The temperatures registered by thermocouples might be a little low, due to the fact that a thermocouple will radiate heat to a cooler object if brought sufficiently close. In the tests it was endeavored to keep the thermo-

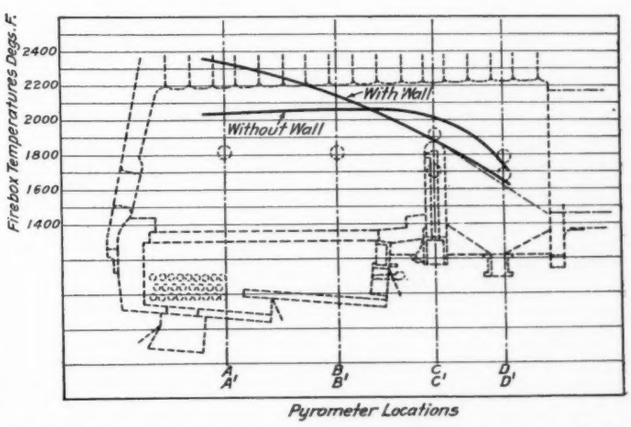


Fig. 2—Firebox Temperatures With and Without the Gaines Wall.

couple far enough away from the crown and side sheets to prevent this loss of heat by radiation; but it is barely possible that some radiation did occur, and that the temperatures registered are a little lower than the actual.

BOILER PERFORMANCE

Advantage was taken of the opportunity to make some determinations of the evaporative efficiency of a boiler, with and without the Gaines wall. The results of the test are summarized in Table II. With the wall in place, an average of 3,675 lb. of oil per hour was fired, with an apparent evaporation of 47,968 lb. of water; this being equal to an

evaporation of 13.05 lb. of water per pound of oil and 12.47 lb. of water per square foot of heating surface. With the wall removed and the same front end draft, the average amount of oil fired was 4,142 lb., with an apparent evaporation of 46,842 lb. of water per hour, or 11.3 lb. of water per pound of oil and 12.18 lb. of water per square foot of heating surface.

The boiler horsepower generated per cubic foot of firebox volume averaged about 4.2; while the equivalent evaporation per pound of oil averaged 17.03 with the wall and 14.8 without the wall, the corresponding boiler efficiencies being 85.5 and 74.3—or a difference of 13½ per cent. in efficiency, due to the Gaines wall.

The boiler efficiencies are high, considering the rate of firing; but it should be borne in mind that in burning oil there is no loss through grates and ashpan and no discharge of fuel at the stack in the form of cinders. With the wall in place, combustion was perfect; there being no indication of CO (carbon monoxide) in the flue gases, and no black smoke issuing from the stack at any time. Under these conditions, practically all the heat loss will be accounted for in the front end gases; and, as shown in Table I, the front end temperatures were uniformly low, considering the length (18 ft.) of the flues. With the wall in place, the average front end temperature was 585 deg.; without the wall, 615 deg.; a difference of 30 deg., which accounts for a part of the efficiency shown by the wall.

With the wall removed, smoke emission was very noticeable; and there was considerable fuel wasted, due to the face and large firebox volume will absorb more heat than a similar firebox without a combustion chamber, thereby reducing the temperature of the gases entering the flues. Since, under a given set of conditions, there is a direct relation between the temperature of the gases entering the flues and leaving at the front end, this results in lower front end temperatures and higher boiler performance.

Table II—Evaporation, Boiler Horsepower and Boiler Efficiency

Test No.	Gaines Wall	Oil— Lbs. Fired Per Hr.	Oil— Lbs. Per Hr. Per Cu. Ft. Firebox Volume	Water—Apparent Evaporation Lbs. Per Hr.	Per Lb. of Oil	Per Sq. Ft. Evap. Surf.	Equivalent Evaporation From and at 212 deg. Lbs. Per Hr.	Per Lb. of Oil	Per Sq. Ft. Ht. Surface	Boiler Horsepower Total	Per Cu. Ft. Firebox Vol.	Boiler Efficiency
1	With	3,139	7.25	41,697	13.25	10.84	54,206	17.30	11.45	1,571	3.63	86.8
2	With	4,004	9.25	52,720	13.16	13.70	68,536	17.11	14.48	1,986	4.59	85.8
3	With	3,956	9.12	50,241	12.17	13.06	65,815	16.65	16.65	1,907	4.40	83.5
4	With	3,607	8.33	47,216	13.09	12.27	61,852	17.14	13.07	1,792	4.13	86.0
Ave.	With	3,675	8.49	47,968	13.05	12.47	62,602	17 03	13.22	1,814	4.19	85.5
5	Without	4,135	9.56	47,500	11.48	12.35	62,225	15.05	13.15	1,804	4.16	75.5
6	Without	4,008	9.25	46,036	11.48	11.97	60,307	15.04	12.74	1,748	4.03	75.5
7	Without	4,164	9.61	44,607	10.71	11.60	58,435	14 03	12.35	1,694	3.91	70.4
8	Without	4,261	9.84	49,227	11.55	12.80	64 487	15.13	13.62	1,869	4.31	75.9
Ave.	Without	4,142	9.59	46,842	11.30	12.18	61,363	14.81	12.96	1,779	4.10	74.3

The indications are that with a combustion chamber fire-

short-circuiting of the oil from the burner into the lower flues, partly unconsumed. Calculations based on the rate of flow of heat through fire brick and boiler lagging indicate that less than 1 per cent. of the fuel used was lost by radiation through the pan and through the boiler lagging.

AIR SUPPLY

Air used for combustion was drawn in through dampers 1 and 3, the pipe thimbles in the rear of the fire pan and the air ducts in the Gaines wall, as shown in Fig. 1. Damper 2 was kept closed during the tests, as it was found that air admitted at this point caused a violent drumming in the firebox. The total effective air opening was 540 sq. in., and this was found sufficient to burn 4,000 lb. of oil per hour without making smoke. The gas analysis indicated an air excess of about 40 per cent.

FRONT END TEMPERATURES

The relatively low front end temperatures obtained show clearly that the long flues are not necessary for low front end temperatures and high boiler performance. These engines had flues 18 ft. long; and the results show that a flue of this length, used in conjunction with a firebox equipped with a combustion chamber of ample length and volume, will give as low front end temperatures as longer flues used in conjunction with a firebox without a combustion chamber. This is due to the fact that a firebox equipped with combustion chamber and providing a large area of heating surbox of this type, with an air opening of one square inch per gallon of oil burned, 4,000 lb. of oil can be burned per hour without making smoke. Without the wall, considerable smoke was made at this rate of firing.

Firebox volume is a very important factor in burning oil. These tests indicate that not more than 9 to 10 lbs. of oil per cubic foot of firebox can be completely burned per hour. This is equivalent to 4 to 4½ boiler horsepower per cubic foot of firebox volume.

Furnace conditions with the Gaines wall in place are almost perfect; and with firing of ordinary intelligence, these locomotives can be driven to maximum capacity with high boiler efficiency and without smoking.

The firebox temperature determinations made in these tests open up a new and unexplored field of research work, which if followed out will add greatly to our rather limited fund of knowledge and will remove much of the guess-work that is now involved in firebox and boiler design.

It should also serve to stimulate the design and manufacture of high-temperature thermocouples, and ultimately result in the evolution of an instrument that is reliable and rugged enough to make firebox temperature readings under road service conditions.

CONCLUSIONS

The following conclusions may be drawn from the results of these tests:

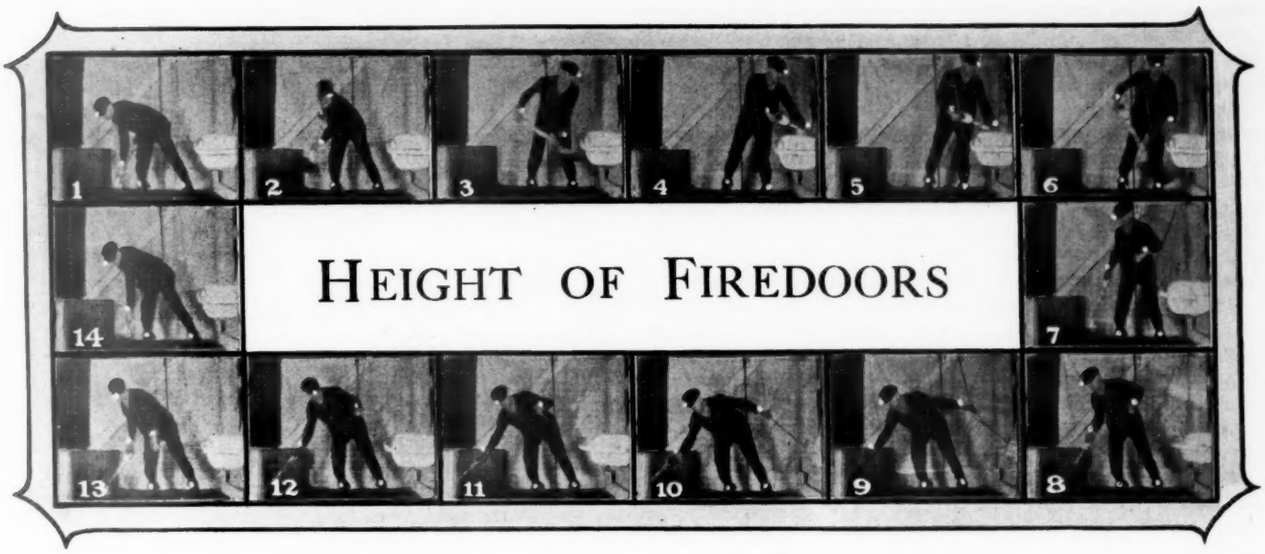
When burning oil, there is no localization or building up of temperatures above the Gaines wall, the highest temperatures being obtained in the back of the firebox and gradually decreasing as the flames approach the flue sheet.

Without the wall, temperatures are more uniform from the door to the combustion chamber, with a decided drop in the combustion chamber. The temperatures above the wall location were higher without the wall than with the wall in place.

Removal of the wall causes a decrease of 13½ per cent. in evaporative boiler efficiency. This is accompanied by an average increase of about 30 deg. in the front end temperatures and a noticeable increase in the amount of smoke.

The wall seems to have little or no effect on the superheat in steam, as these temperatures average from 225 to 230 deg. with the wall in place to 225 to 235 deg. with the wall removed.

Canadian Railwayman Honored.—Lieut.-Col. C. W. P. Ramsay, chief engineer for construction, Eastern lines, C. P. R., and now with the Canadian Army in France, has been made a Companion of the Order of St. Michael and St. George.



HEIGHT OF FIREDOORS

THE fact that the distance from the cab deck to the bottom of the firedoor varies on our modern locomotives from 17½ in. to 26 in. shows that no very great consideration has been given to this particular feature of locomotive design. It has, however, an important bearing on efficient locomotive construction, for with an improperly located firedoor the fireman cannot perform his work efficiently. In order to determine as near as possible the proper height at which the firedoor should be located, the Pennsylvania Railroad conducted some unique tests at its Altoona test plant which give without question the most authoritative information on this subject. These tests show that regardless of the height of a fireman, freer action of the arms and body will be obtained with the bottom of the firedoor located 22 in. above the cab deck and that the coal should always be within reach of the fireman.

The tests were made on a firing platform which had the dimensions of the cab and tender of a class L-I-S (Mikado) locomotive, the back head of the boiler being arranged so that the firedoor could be raised or lowered by the man shoveling the coal. The coal was placed on the platform at about the same location as the coal gates on the locomotive. The box that corresponded to the grates was given the same slope as on the locomotive and an improvised brick arch was used, being properly located with respect to the grates and back head of the boiler.

Twenty-four road firemen, six from passenger and six from freight service on two divisions, were called in to operate on the test platform. Each man fired coal for intervals of 15 minutes at firing rates of 5,000 and 9,000 lb. of coal per hour. They were instructed to set the firedoor at the height which best suited them. The results of these tests were plotted and it was found that with the two rates of firing, the desired height of the firedoor above the cab floor varied between 18 in. and 25 in. No definite relation between the height of the men, which varied between 5 ft. 5½ in. and 6 ft. 3 in., and the height of the firedoor could be found. Some special duty firemen and the test plant firemen, who were taller than the road men, preferred a low door. It was also found that those men who had been operating engines with high firedoors were generally higher in their choice than those operating locomotives with the low firedoors. The average height of the firedoor chosen in these trials is in the table.

	Number of Men	Average Height of Firedoor	
		5,000 lb. Rate	9,000 lb. Rate
Division A firemen	12	22.89 in.	22.09 in.
Division B firemen	12	22.93 in.	23.01 in.
Special firemen	6	20.66 in.	20.85 in.
Average	..	22.46 in.	22.21 in.

MOTION PICTURE STUDIES.

In addition to these tests an analysis of the movement of three expert firemen when firing with the bottom of the firedoor set at heights of 18 in., 22 in. and 25½ in. above the cab deck were made from motion pictures taken during the operation. The firemen were 6 ft. tall and fired at the rate of 5,000 lb. of coal per hour.

The film showed approximately 75 positions of the fireman during a complete cycle, i. e., from the time coal was taken from the firing platform, delivered to the firebox and the shovel returned to the coal pile on the platform. From the film, which had been previously exposed to specially prepared co-ordinate paper, the path traveled by any portion of the fireman's body could be plotted. The photographed images of miniature incandescent lamps fastened to the head, wrists and ankles of the fireman, gave definite reference points on each of the 75 pictures, from which the paths traveled by these parts of the body were subsequently plotted. A sample of the films obtained is shown at the head of this article.

The path traveled by the head, which represents the movement of the man's back, and that traveled by his left hand, which opens and closes the firedoor and lifts the shovel, have been plotted for the three heights of firedoor in Figs. 1, 2 and 3. Only that portion of the movement during the delivery of the coal from the firing platform to the firebox is shown on these sheets. The three lower curves on these sheets represent the path of the left wrist of each of the men, while the three upper curves represent the movement of the head.

Referring to the lower curves, the firedoor chain was released at point *X* after the firedoor was opened. The path *X* to *A* was a free movement of the hand; the hand grasped the heel of the shovel at *A*, the shovel was lifted from *A* to *B*, the shovel full of coal was moved from *B* to *C* nearly horizontally toward and through the firedoor to the firebox.

The upper curves *R* to *S* represent the path traveled by the man's head during the time that his left hand was traveling the path *X A B C*. In discussing the curves, the center line *P Q* of the firedoor will be taken as the reference line as it lies midway between the upper and lower limits through which the coal must pass.

Firedoor 22 in. Above Deck Plate.—In Fig. 1 are shown the paths traveled by the head and left hand of the three fire-

men with the firedoor set 22 in. above the deck plate. An analysis of these curves and those determined when the firedoor was set 18 in. and 25½ in. above the deck shows the probable reason for the thirty firemen choosing an average height of firedoor above deck of 22 in. It will be noted in Fig. 1 that the expert firemen all lifted the coal to approximately the name level, *B*. The horizontal difference in the position of the left hand after the coal was lifted from *A* to *B* and in the location of point *R* of the head curves, was due to the difference in the reach for coal. It will be observed that the point *B* in the hand curve in Fig. 1 is slightly above the center line of the firedoor.

As the horizontal movement shows a tendency to be parallel to the line *P Q* from *B* to *C*, it seems that the location of point *B* determines the natural height *A B*, to which the coal would be raised during its delivery. Otherwise stated, the height *A B* is the natural vertical lift and ordinarily will be approximately the same height regardless of the height of the firedoor. The curves *R S* show a natural movement of the back. There is a uniform rise from *R*, where the head is at its lowest position, to *S* the point of maximum height. The head curves indicate that the man's back was gradually straightening during the delivery and taken in conjunction with the lower (wrist) curves, indicate that the lifting of the

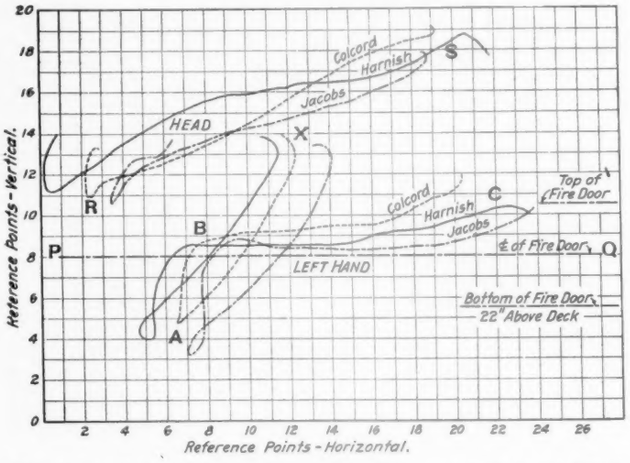


Fig. 1. Analysis of the Motion of the Head and Left Hand When Firing Through a Firedoor 22 in. Above the Cab Deck

coal from *A* to *B* and the delivery from *B* to *C* was accomplished by muscular action of both arms and back.

Firedoor 18 in. Above Deck Plate.—The paths of the head and left hand when the firedoor is set 18 in. above the deck plate are given by the curves in Fig. 2. Here the vertical lift *A B* is different for each fireman, although all raised the shovel from approximately the same point *A*. Fireman Jacobs raised the coal approximately the same height as he did for the 22-in. door, and in his horizontal movement gradually lowered his left hand until near the point where the coal left the shovel. His head curve is similar to the one for the 22-in. firedoor. The head and hand curves for fireman Jacobs when firing through the 18-in. firedoor, are similar to those on the 22-in. firedoor, but at the lower height of door there is more bending of the knees during the delivery from *B* to *C* and in this respect his position is more cramped than when the firedoor is 22 in. high.

Firemen Colcord and Harnish did not raise the coal as high in this case as they did for the 22-in. firedoor; the path of delivery *B C* is similar to the one for the 22-in. firedoor, but the back movement appears unnatural and indicates that they crouched more or less while working and that there was little back movement while the coal was traveling the path *A B C*.

Firedoor 25½ in. Above Deck Plate.—The curves when firing with the firedoor 25½ in. above the deck plate are shown in Fig. 3. All the men lifted the coal approximately the same height *A B;* the maximum height *B*, at the initial lift was below the center line of the firedoor. The horizontal movement *B C* shows a greater rise than for the lower height doors. This movement must have been a combination of

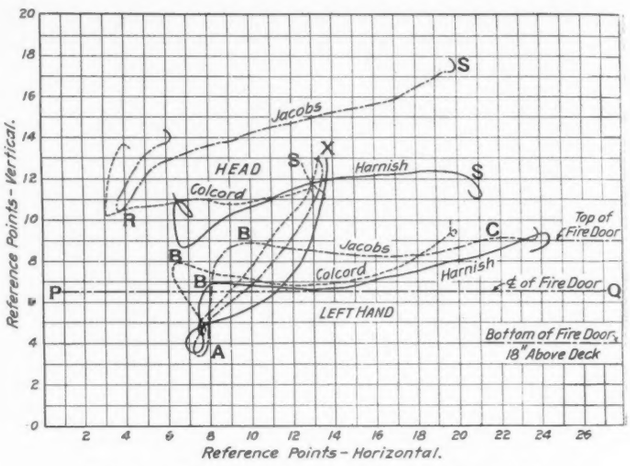


Fig. 2. The Same as Fig. 1 for the 18-In. Height

muscular effort, to raise the coal to and above the reference line *P Q*, and pivot action of the arms.

The motion pictures from which the curves were plotted show that there was a decided upward movement of the right hand near the point where the coal left the shovel, this movement being necessary in order to lower the bowl of the shovel. This upward movement of the right hand was not so noticeable when firing through the 18-in. and 22-in. doors.

CONCLUSIONS

It appears from the motion study that with the bottom of the firedoor 22 in. above the deck plate, the fireman lifts the

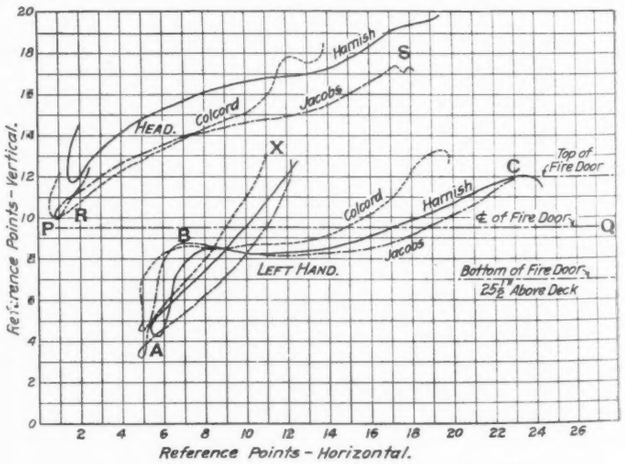


Fig. 3. The Same as Fig. 1 for the 25½-In. Height

coal with greater ease due to the combined muscular effort of the back and arms and the movement in delivering the coal is more uniform. False movements of the shovel are a minimum. With this height the coal is lifted to a natural height, *B*, and there is a natural use of the delivery curve *B C*, due to the pivot action of the arms at the shoulders. This height of door will be satisfactory to the average fireman as was shown in the firing tests in the laboratory.

As disclosed in all three of these plots, location *A*, the position of the left hand when lifting the scoop of coal should be the same for each action regardless of the firedoor height.

CROSS BALANCE OF LOCOMOTIVES

BY C. H. FARIS

Counterbalancing of locomotives was the subject of investigation by a committee of the American Railway Master Mechanics' Association in 1914 and 1915, and the results of their investigations and experiments are given in the proceedings of the associations for 1915, pages 341 to 349.

During the discussion of the report, the chairman of the committee stated that an endeavor had been made to omit from it, for simplicity, all technicalities and refinements. One of the refinements referred to related to the practice of advancing the position of the counterbalance weight a small angle from diametrically opposite the crank pin for certain advantages of cross balancing. So far as the recommendations of the committee were concerned, the chairman said this could be done if thought necessary.

The purpose of this paper is to point out the advantages of this practice and an endeavor to state in such clear and simple manner the fundamental principles and reasons for

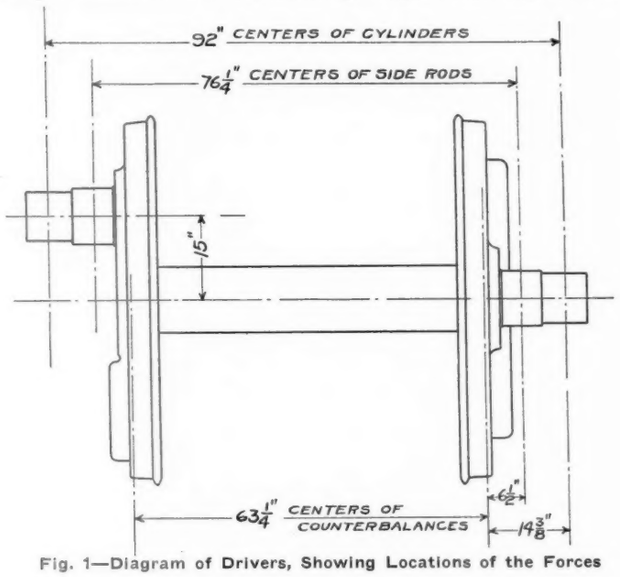


Fig. 1—Diagram of Drivers, Showing Locations of the Forces

such practice as will make them more generally and better understood than they seem to be at present.

The forces that must be counteracted in engine balancing are those due to rotating and reciprocating parts. The end sought is the elimination or reduction of the swaying and vibrating effects on the engine body by disposing the positions and directions of these moving parts so that their mutual actions and reactions will counteract each other.

The exact amount of the centrifugal force exerted by a rotating body can be computed if we know the weight of the body, its speed and the radius of its path of rotation. The formula is:

$$F = W R \frac{V^2}{G} \qquad (1)$$

where F is the centrifugal force in pounds, W is the weight of the body in pounds, R is the radius in feet or the distance in feet from the center of rotation to the center of gravity of the body, V is the angular velocity measured in radians per second, and G is the acceleratiton due to gravity, or 32.16 ft. per sec. per sec. If in place of V in radians per second, we substitute N for revolutions per minute, and in place of G, its value of 32.16 formula (1) becomes:

$$F = .000341N^2WR \qquad (2)$$

When we consider the relations to each other of a set of centrifugal forces in a balancing problem having the same center of rotation and fixed radii we find that the forces due to the different masses all vary in the same proportion as the speed. For this reason balancing problems are usually worked out by using only the product of WR for each mass, the full expression for the centrifugal force being computed only when its actual value at a given speed is desired. Any set of masses in balance for one speed will be in balance for all speeds. However, a set of masses which are but slightly out of balance may effect a disturbance, which may become quite serious at high speed.

It is impossible to balance completely a reciprocating mass by a rotating mass, and for this reason it is general practice to attempt a compromise by leaving a part of the reciprocating masses unbalanced, which gives rise to swaying or vibrating forces in the horizontal plane. At the same time the rotating overbalance which balances a part of the reciprocating forces in the horizontal plane introduces unbalanced forces in the vertical plane. Since the purely rotating masses can be completely balanced, it is the reciprocating masses which are the principal cause of disturbing forces. For this reason considerable effort has, of late, been made to reduce the weight of reciprocating masses.

In addition to the disturbing forces due to the reciprocating masses, which for ordinary two-cylinder locomotives cannot be eliminated, usual American practice of counterbalancing has another source of vibrating and disturbing forces which can be eliminated by shifting the position of the counterbalance from its usual position.

This source of disturbance is due to the fact that the counterbalance cannot be placed in the same plane of rotation with the side and main rods and other parts which it is intended to balance, but is in a plane parallel to the plane of rotation of those parts. And since the centrifugal forces of these two sets of weights are opposite in direction the distance between their lines of action forms the arm of a couple. In many of our heavy modern locomotives this distance has become considerable and the resulting unbalanced couple becomes too great to be neglected.

Fig. 1 is a diagram of the main drivers and axle of a 2-10-2 type locomotive, showing the planes of motion of the reciprocating weights, main and side rods, and the planes of rotation for the counterbalances.

The data for this engine, which concerns counterbalancing, is as follows:

Size of cylinders	29½ in. diameter by 30 in. stroke
Total weight of engine	375,000 lb.
Weight of reciprocating parts for one side, including the reciprocating part of the main rod	1,925 lb.
Amount of reciprocating parts balanced	60% of 1,925 = 1,155 lb.
Amount of reciprocating parts unbalanced for one side	40% of 1,925 = 770 lb.
Total weight of main rod	1,162 lb.
Rotating part of main rod	762 lb.
Total weight of side rods, pins and details for one side	2,941 lb.

The weights to be balanced on each side fall in two planes. In the plane of the center line of the cylinder are 60 per cent. of the reciprocating weights and the rotating part of the main rod, which amount to 1917 lb., and in the plane of the side rods are the rotating weights, made up of side rods, pins and details, which amount to 2,941 lb. In addition to these two sets of weights the counterbalance must be increased to provide for the extra weights of the crank pin hubs and the contained parts of crank pins. In what follows only those weights in the planes of center lines of cylinders and side rods are considered. Since for the present we are only concerned with the problem of balancing the couple due to the eccentricity of the position of the counterbalance, the forces due to unbalanced reciprocating parts and those in the vertical plane due to the overbalance are neglected. Their effects can be investigated separately.

Fig. 2 is a diagram showing the relation of the balanced forces. F_1 represents the centrifugal pull due to the rotating part of the main rod and that part of the reciprocating weights which we wish to balance. It is equal to $.000341N^2R \times 1917$. For the present we are considering the total weights on each side. The final solution must consider separately the forces and weights for each set of

drivers. F_2 is the centrifugal force due to the total weights of the side rods and their details and is equal to .000341 $N^2R \times 2941$. B is the centrifugal force due to the counterbalance weight, which was made equal to $E_1 + F_2$, or .000341N^2R (1917+2941). Evidently the couple due to these three forces is equal to $F_1a_2 + F_1a_2$. Substituting the values of a_1 and a_2 from Fig. 1 in feet and for F_1 and F_2 as above this couple becomes .000341 N^2 R (1917×1.198+2941× .542) = .000341N^2R × 3890.6 foot pounds.

The maximum value of the force due to the unbalanced reciprocating parts on one side is .000341N^2R×770. This force produces a couple tending to sway the engine horizontally about the vertical axis through the center of gravity and is equal to .000341N^2R770 × 3.833 = .000341N^2R × 2951.4 foot pounds, which is less than the couple due to eccentricity of balance weight as found above. For this particular engine the unbalanced couple due to eccentricity of position of the counterbalance is 31.8 per cent greater than the couple due to the unbalanced reciprocating weights.

It will be noted that these two couples—that due to eccentricity of counterbalance and the one due to unbalanced reciprocating parts—do not oppose each other in their action, but that they pull together so that the total couple tending to rock and sway the engine is equal to their sum or is .000341N^2R×6842.0 foot pounds.

Obviously if the unbalanced couple due to eccentricity of position of the counterbalance can be eliminated, as much would be accomplished as could be possible by a considerable reduction in the weight of the reciprocating parts. That this can be done will be shown as follows: In Fig. 3 the parallel forces F_1 and F_2 of Fig. 2 have, for simplicity,

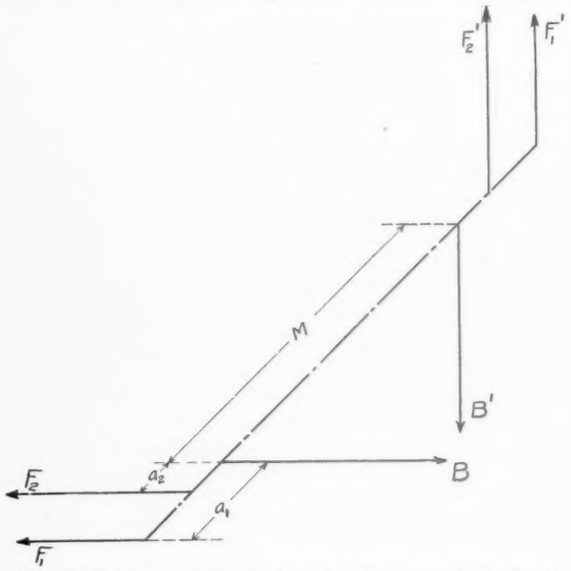


Fig. 2—Relation of the Balanced Forces to Each Angle

been replaced by a single force F, which may be taken to represent the resultant of F_1 and F_2. The force B represents the centrifugal pull due to the counterbalance, which has been moved an angle A from the usual position directly opposite the crank pin, as shown. The pull of the counterbalance in its new position will be the same in effect upon the axle as the two components C and G. Taking moments about the point O, the eccentric couple of the counterbalance, which is equal to $F \times a$, will be neutralized when the component C has such a value that $F \times a = C \times M$, from which

$$C = \frac{F \times a}{M} \tag{3}$$

The couple of F^1 about O will be balanced when $G \times M = F^1 (M + a)$ from which

$$G = \frac{F^1 (M + a)}{M} \tag{4}$$

The value of B can then be found from the relation.

$$B = \sqrt{C^2 + G^2} \tag{5}$$

Since F and F^1 are equal, C, G and B can be found when a, M and F are known. In this case F represents the centrifugal force due to the weights of reciprocating and rotating parts which are to be balanced.

The value for B representing the centrifugal force of the counterbalance will be found to be somewhat greater for the

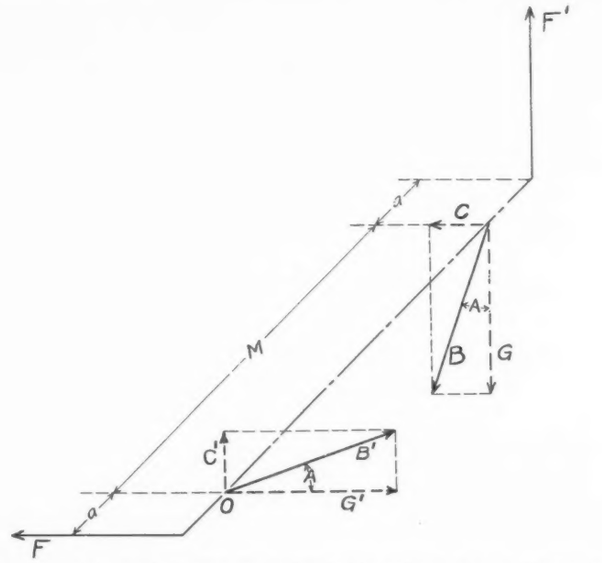


Fig. 3—Relation of Forces with Counterbalancing Moved Through Angle A from its Usual Position

conditions shown in Fig. 3 than for the conditions shown in Fig. 2.

The angle A representing the offset for the position for the counterbalance can be found from

$$\text{Tan } A = \frac{C}{G} \tag{6}$$

or substituting for C and G from equations (3) and (4) and reducing,

$$\text{Tan } A = \frac{a}{M + a} \tag{7}$$

The committee of the American Railway Master Mechanics' Association referred to above, as the results of experiments, has recommended that the total weight of reciprocating parts on each side of the locomotive be kept below one one-hundred-sixtieth part of the total weight of the locomotive in working order, and that one-half of the weight of the reciprocating parts be balanced.

It is this amount of unbalanced reciprocating parts which the committee's experiments indicated would not produce objectionable swaying couples. But since there is nothing to indicate that any account was taken of the effect of the couple due to eccentricity of the position of the counterbalance a considerable part of the total swaying couple, as we have seen, may be made up from this cause as well as from the direct effect of the unbalanced reciprocating weights. If the eccentric couple is eliminated by advancing the counterbalance a proper angle it may be possible to leave unbalanced a considerably greater amount of the reciprocating parts than the experiments of the American Railway Master Mechanics' Association committee would indicate.

Any increase in the amount of the reciprocating parts that can be left unbalanced means a corresponding reduction in the amount of over-balance put into the driving wheels and a corresponding reduction in dynamic augment or "hammer blow," which is important in locomotives with heavy wheel loads.

STEEL CAR SHOP OF THE E. J. & E.

Methods Used to Increase the Capacity of the Plant
Interesting Application of Some Portable Riveters

MANY railroads at this time find themselves confronted with the necessity of increasing the output of the car shops in order to furnish the rolling stock required to handle the present heavy traffic. With tools, materials and men so hard to get, the problem is by no means an easy one to solve. The way in which the Elgin, Joliet & Eastern increased the capacity of its plant for repairing steel cars at Joliet, Ill., is therefore of particular interest.

Under normal conditions the repair tracks formerly made heavy repairs to about 100 steel cars each month. The great increase in the ore and coal traffic made it necessary to keep every available car in service and plans were made for increasing the capacity of the plant to handle about 200 cars a month. The capacity of the tracks was about 180 cars and this was increased to about 320 cars by adding 11 short tracks to the repair yard. Narrow gage tracks were arranged to serve the repair tracks, one being placed between every second track and one running transversely across all the tracks. Sheds open on the sides, with louvres to admit light and air, were built to cover half the tracks.

For purposes of organization the repair yards are divided into two sections, each under the supervision of a foreman. These sections consist of 12 tracks, each having a capacity of about 13 cars. When the cars are set on any of the tracks for repairs they are not moved until all are finished. About two days are usually allowed for stripping, two for reassembling and two for painting the cars, but this allowance is increased when new sills are required.

The cars on which the majority of the work is being done are of two different designs, one a side dump car, shown in the process of stripping in Fig. 1, the other a bottom dump, shown in Fig. 2. Most of these cars were built 14 or 18 years ago and are receiving their first overhauling.

The Day's Output Ready to Leave the Repair Track

As soon as the cars are placed on the repair tracks they are inspected to determine what parts are to be removed. The majority of the sheets are 5/16 in. thick when new and they are renewed if the thickness is 3/16 in. or less. The principal parts of the cars which require renewal are the side sheets, dump doors and floor sheets. These parts are made in quantities and carried in stock for all classes of cars. All rivet holes are punched according to templets and reamed after being placed in position. Dump doors, sills, etc., are assembled complete ready for application.

The shop was well supplied with punches and shears,

there being 12 of these machines ranging in size from 21 in. to 56 in. There were also two coping machines, one double angle shear, one 200-ton hydraulic press and three drill presses.

Since the forming operations could not all be done on the

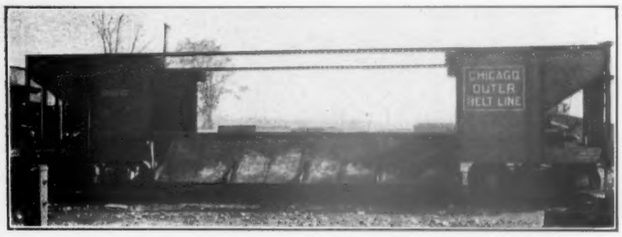


Fig. 1—Side Dump Car Being Stripped for Repairs

hydraulic press it was necessary to provide some means of doing this work. The pneumatic press designed for this purpose is shown in Fig. 3. A double-acting air cylinder operates the bar, the height of which can be adjusted at

Fig. 2—Bottom Dump Car Ready for the Application of New Sheets

either end. Formers of various types have been developed for use with this device, thus adapting it to a wide range of work. In the illustration it is shown closing up the end of a channel which forms part of a bolster.

The riveting of the dump doors and similar parts is han-

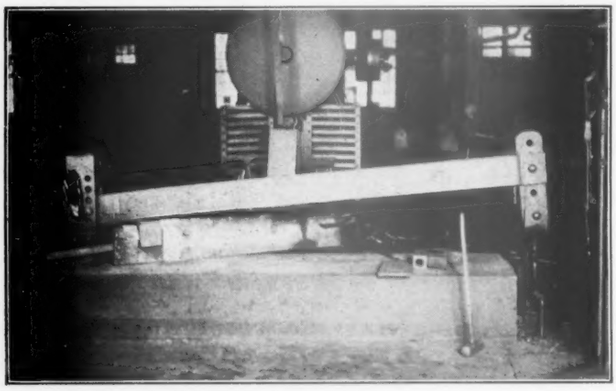


Fig. 3—Pneumatic Forging Press Adapted to a Wide Range of Work

dled in a novel manner. The method used on dump doors is illustrated in Fig. 4. After the doors are assembled trunnions are bolted on each end near the center. The doors are then placed on horses directly under a portable air riveter, being supported by the trunnions, while a hinged dog attached to one of the horses keeps the door from turning on its supports. The riveter is supported overhead on a rail, along which it can be moved, while the height is adjusted by a chain hoist. When the rivets in the upper half of the door have been driven it is revolved on the trunnions to bring the other end up. In this way it is possible to handle the work with riveters having a reach equal to only one-half the width of the parts which are riveted. The work is done more rapidly than where air hammers are used and much better workmanship is secured.

The application of the air riveters to the riveting of center

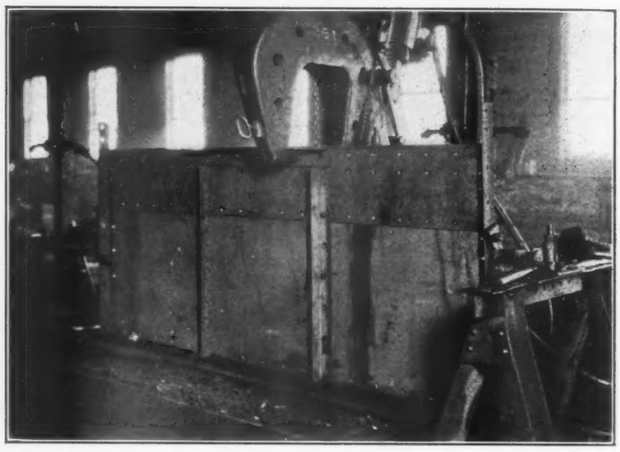


Fig. 4—Riveting Dump Door on Trunnion Supports

sills is shown in Fig. 5. Here the riveter is suspended at a fixed point and can only be moved vertically. The work after being assembled is mounted on strong push cars and moved along under the riveter. Some of the push cars are fitted with trunnion supports and in case all the doors cannot be handled on the horses some are mounted on cars and finished at the stationary riveter.

The assembling of the cars is done by gangs consisting of

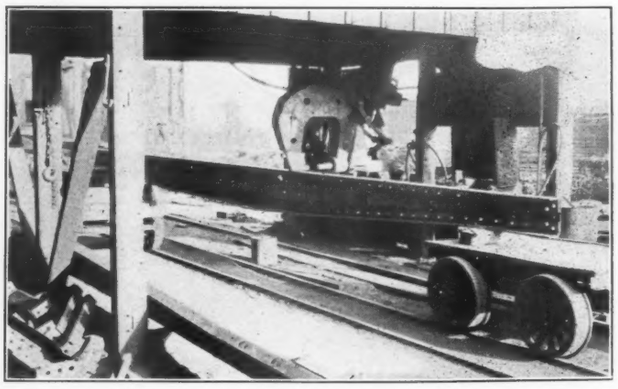


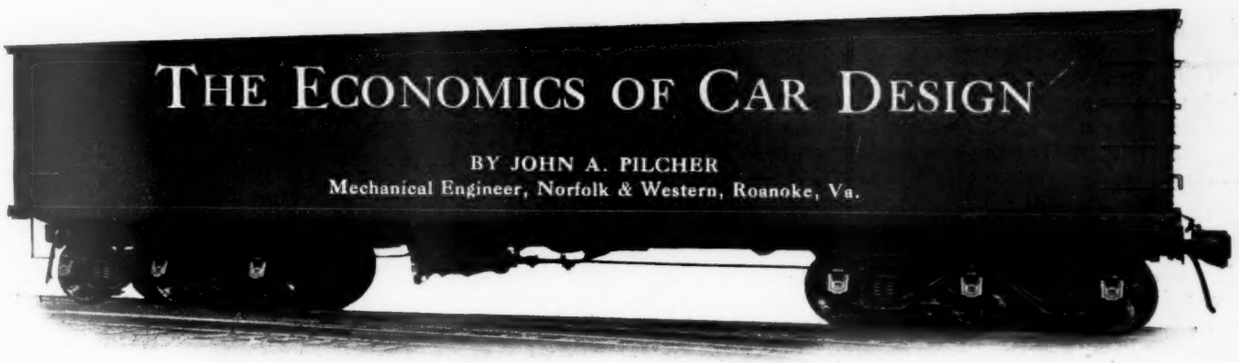
Fig. 5—Method of Handling Center Sells in Pneumatic Riveter

four fitters and two riveters. The parts are placed in position by the use of cranes and jacks and riveted with air hammers. The exterior is then given two coats of paint.

The work that is being done on the E., J. & E. is a splendid illustration of what can be accomplished under the present conditions to get greater production from labor and tools. The increase in the output of the shop is due to the ingenuity that has been used in designing special tools for the more important work, in devising effective methods of using the class of equipment that was available, in arranging for producing parts in quantities, and in maintaining a definite system for routing parts through the shop.

THE ECONOMICS OF CAR DESIGN

BY JOHN A. PILCHER
Mechanical Engineer, Norfolk & Western, Roanoke, Va.



WHEN consideration is given to the very large number of freight cars built from a single design, the importance of giving careful study to each detail is readily understood. Every small saving that can be made in the labor of construction, each slight saving that can be made in the weight of the material, and every case where unnecessary material is used, as well as every slight defect, is multiplied by a thousand, in many cases by two or three thousand, or more. The large expenditure of money involved in the building as well as in the operation and upkeep of the cars which may be represented by a single design, justifies the thought of the best designers for an unlimited amount of their time.

The writer has a case in mind in which the slight shifting of the location of two rivets in a single detail, used several times on the car, made a difference in the cost of an order of 1,000 cars of more than $2,000. How easy it is for the draughtsman or designer to let such a small matter go, rather than to take the time to make a slight change, which in this case had no influence whatever on the strength or maintenance of the structure, overlooking the extent to which his time will be repaid by the slight saving in the cost of the detail involved when such a large multiplier is used!

An experienced and enthusiastic car designer once said to the writer that he could take any car design, whether made by himself or another, and by again carefully going over every detail, save enough on an order of 1,000 cars to pay himself handsomely with 10 per cent of the reduction in the cost of construction, without reducing the strength of the structure in any way.

WHY THE RAILROAD SHOULD DO ITS OWN DESIGNING

The design for any type of freight car may be laid out along many different lines, each of which must be developed in great detail, and some in complete detail, before a proper and intelligent selection of the best for the purpose can be made. When the general type of construction has been determined there are then a large number of details, each of which should be given careful study from many angles. How is this study to be made? Who is to make it?

At the outset it must be clear that time is a most essential element in the solution of the problem, no matter to whom or what agency the task is to be given. No one can make a comparative study of several types of construction, each involving many details, without a liberal allowance of time. Such an allowance of time can only be had when the designer has his problem before him well in advance of the actual requirements of the equipment. This work must be done before the production of the working drawings becomes necessary.

Rushing through the design of a new car in order that the material may be ordered for quick delivery and the contract brought to an early completion is probably the most prolific of all sources of unnecessary expense, both in first cost and maintenance. It cannot be expected that each of the many car-building organizations will maintain a sufficient staff, necessarily getting its information second-hand, to make an advance study of the many special needs of each railroad that may become a purchaser of cars.

In many cases the result is that plans are quickly prepared to meet an early date set for the receiving of bids, and regardless of the ability and experience of the designer, it invariably is found in such instances that less material could have been used with even greater strength or that there are real weaknesses in the design which could have been made amply strong without the use of additional material. Neither the bidder who fails to secure the contract nor the successful bidder has the time or opportunity to modify the design after the contract is let. Any change then made brings about correspondence, adjustment of price and delay.

For the following reasons, therefore, any railroad ordering as many as 1,000 cars of the same type at one time is fully justified in maintaining its own engineering force, made up of as many men as can be used, and in holding the best men who can be obtained:

(1) The men in this organization can easily be kept informed as to the probable special needs of the road. They can be preparing to anticipate these needs and experimenting with the equipment with that end in view. They may thus have definite general plans formulated and ready when the need arises.

(2) They have opportunities for first-hand information as to the relative effectiveness of different types of equipment and details under the service conditions of their own road.

(3) They are in a position to appreciate fully all phases of the problem, whether it be low first cost of construction, which means light weight and, therefore, low cost of operation, or low cost of maintenance, which means ample structural strength and proper provision for deterioration.

(4) They are also in a position to keep in close touch with the methods and appliances used in the road's shops, keeping these in mind when the design is made in order not to require the introduction of new methods or tools unless necessary; they are also in a position to know what older or standard parts should be retained in new designs. Frequently much money is expended in constructing a difficult detail in the shops, which could have been saved had the designer been familiar with his shop equipment.

(5) The railroad by going into the market to purchase a specific design completely worked out in detail, with complete specifications, receives the advantage of real competition, as the only considerations are the reliability of the bidder and the price. This also effects a large saving of

time, as each bidder is not required to prepare a new design before making the estimate.

The economic and engineering problems of freight car design are primarily two—cost and strength. While here considered more or less separately, they cannot properly be considered separately when an actual design is being worked out.

STRENGTH AND COST OF MAINTENANCE

Some years ago there came into the office of the writer an old man, an engineer representing a manufacturer of a device for railway use. In the course of his conversation he made the statement that when a young man he had been told by an older man always to be sure that he made everything very strong. If a structure never broke down its cost was never questioned in after years, but if it proved to be not strong enough it would always stand as a record against him. If an engineer is preparing a design for a single structure and the factors limiting the strength are difficult and expensive to determine closely, he is justified in insuring safety even at considerable extra expense over what might be a perfectly safe design, were a more accurate knowledge of the stresses available. To handle a problem in freight car design in this manner, however, is not engineering at all. The commission to design a freight car, when large numbers are to be built from the design, warrants all the diligence and expense necessary to determine with certainty the limitations within which the strength of the design must come in order that the weight and corresponding first cost, cost of maintenance, and cost of operation, may be properly compromised.

There are certain details of the car, both the truck and body, that are either fixed as standard or recommended as good practice by the Master Car Builders' Association. Where the standard has been established, as in the case of the axles, brasses, boxes, brake shoes and heads, couplers, brake pins, etc., any departure, even for special cars, must be carefully considered to avoid all complications and delays under the M. C. B. rules of interchange.

Recommendations in the matter of practice take care of nearly all other truck details, either fixing the tests they must withstand or space they may occupy, or both. To the springs, however, I wish to call especial attention. They should be of such capacity that under no conditions of operation will they ever go solid. The solid closing of the springs puts stresses in other members of the truck which they are not designed to take and which cannot be predetermined. Inattention to this matter may lead to broken side frames and bolsters.

In the car body construction the coupler and its location are practically the only important exact standards adhered to. Since the stresses in the body structure are of such an indeterminate character, depending so largely on the treatment the car receives in service, the Master Car Builders' Association has placed recommended minimum limitations for the construction of the center sills, to discourage the building of cars not sufficiently strong to be used without trouble in interchange traffic. The recommended minimum is based upon a maximum load in the center sills of 500,000 lb., and a combined maximum fibre stress due to this load of 30,000 lb. per sq. in. The minimum sill area is placed at 24 sq. in., the ratio of stress to end load at .06, and the maximum unsupported length of the center sills at 20 times the width. It may be stated in passing that this should also apply to the depth.

It is fortunate that the car designer has a measure of the buffing stresses fixed for him, as no construction he may use will insure freedom from failure if the cars come together at sufficient speed.

It is not the purpose of the writer to go into the details of construction. There are, however, a number of fundamental considerations which the designer should keep in mind as a means of properly directing his study, which it may be well to point out.

(1) Every stress imposed upon the car from without as well as every stress set up in the car from the load it carries, or from changes of speed or direction while either loaded or empty, sets up a reaction at one or more points in the car and must be resisted in some way. This is so fundamental as hardly to need statement, and yet it requires the closest study to determine all the points of reaction and all the effects of a stress. All the vertical and lateral forces must finally be transferred to the rail. All the longitudinal forces must either be passed on to an outside object, absorbed as work done within the car structure or taken up by the friction of the moving car. Keep in mind the fact that all forces act in straight lines.

(2) In considering longitudinal stresses, the limit of which cannot be definitely determined, there should be a progressive selection of the order in which the parts should fail. For example, the knuckle should break before the coupler, as it is easier to replace. The coupler possibly should break before the coupler attachments, and the attachments certainly before the center sills. If the coupler shank has a section of 15 sq. in. it might be well to put 20 sq. in. in the coupler attachments, particularly to resist the buffing stresses, and thus lead up to the 24 sq. in., which is the minimum recommended practice of the Master Car Builders' Association for the center sills.

(3) Where contact surfaces are in constant motion under heavy pressure the maximum bearing surfaces should be provided, particularly where the development of slack is seriously detrimental to the proper functioning of the parts or is hard to eliminate, as in draft gear connections and friction draft gears. It would be difficult to use so much material, properly distributed around the draft gear connecting parts, that any of it need be considered as wasted material.

(4) Try throughout the structure to so select the number, size and location of rivets as to balance the shearing, bearing and tensile stresses, on the basis of the well established ratios. So place all rivets that they will do the maximum work. Always keep in mind where the failure preferably should occur from the standpoint of maintenance.

FIRST COST AND COST OF OPERATION.

Above all else the car must hold its shape and the parts stay together if it is to give service. All of these points must be considered in the interest of strength, and with a view to reducing maintenance, which means keeping the car in service. But these are not the only considerations. The weight of the car is of great importance and keeping down the weight means not only reduced first cost but a reduction in the cost of operation continuing throughout the life of the car. The writer has in mind two cars designed for the same class of service under the same conditions, one of them the result of continued study through several stages of development, each represented by a complete design, the work covering a period of several years. The result is that the car finally developed represents a reduction in weight of 20 per cent when ocmpared with the first car, 13 per cent when compared with the second design and 10.4 per cent when the third design is considered. This was accomplished without reducing the service value of the car from any standpoint; as a matter of fact, a considerably stronger car has been produced, and it is much simpler in construction.

The revenue load of the first car was 75.3 per cent of the total loaded weight and of the fourth car 77.35 per cent on the cubic capacity basis. With the lading increased in the fourth car to give the same wheel loads as the first, the revenue load was 77.95 per cent of the loaded weight. The

last design effects a direct reduction in first cost of over 10 per cent, and a saving in the cost of operation during the life of the car (assumed as 20 years) of at least one and one-half times the whole cost of the cars, because of the reduced dead weight to be hauled. In addition to this, it offers an opportunity to carry an increased load, due to its lighter weight, which means a very material increase in revenue on every car. In the fourth car, as compared with the best of the other three, there were about 25 per cent less rivets to drive.

The following suggestions are worthy of consideration in reducing the weight, and thereby the cost, without detriment to the service or strength of the structure:

(1) Eliminate as far as possible the lapping of material in joints. Extra material is often used in this way which does not enter into the calculation of strength and which often adds nothing to the strength of the structure. The designer, in an attempt to accomplish this end, is justified in having special shapes rolled when there are a large number of cars to be built, but should study carefully every available merchant shape before resorting to this expedient.

(2) When considering the use of any section, compare it and every other available section to see which gives the required strength with the minimum amount of material. Sometimes the form that appears as most suitable and gives the best finish is the least efficient in strength and weight of material. A freight car is primarily an article of utility, not one of beauty.

(3) See that there are no overhanging ends or corners which are simply extensions of serviceable parts, in themselves, adding nothing to the strength of the car or to its holding capacity.

(4) Reduce the end distance beyond the outside rivet holes on every piece, to the minimum consistent with mill and shop practice. Long end distances on many pieces total up to a large tonnage and frequently require re-shearing.

(5) Consider carefully what allowances should be made for corrosion in metal cars in order to provide against a decrease in strength to keep the car in service for a reasonable lifetime. Remember that where parts can be replaced without too much expense it is cheaper to replace them at intervals than to carry too much dead weight throughout the life of the car and pay interest on the extra investment in first cost for a long term of years.

(6) Consider every part from the viewpoint of repairs in case of wreck damage, taking into account the facilities at hand for producing a new part or repairing the damage part. Where a road has a large number of cars of the same type the necessary facilities for such work can be afforded, but the car may sustain the damage when away from home, where the repairs will hold it out of service for a long time.

A HANDICAP OF THE DESIGNERS

Very frequently the car designer finds himself handicapped by some things which he would like to change. What is now a standard has often become so because of its utility under conditions which no longer exist, or have been materially modified.

An outstanding example of this is the M. C. B. standard coupler with its standard length of shank and standard maximum height above the rail. The height of the coupler was fixed in the days of light wooden cars when the fact that the impact load falls out of line with the neutral axis of the sills was not of serious consequence. Conditions would be greatly improved now, however, if the coupler could be raised even two inches.

The length of the coupler shank was fixed without consideration of the possibilities of larger coupler heads, longer overhang of couplers, draft gears with long travels which add so materially to their capacity, and without regard to the advantages in increased strength of fastenings if these were set further back on the car sills.

It is scarcely to be believed that it was ever the intention of the designer of the first automatic coupler, that the coupler, containing the movable parts of the locking mechanism, should receive the full shock of buffing blows. In the early days of the automatic coupler cars almost universally were equipped with dead blocks. Although later, when switchmen and trainmen were required to go between the cars to manipulate the coupler, the removal of the dead blocks may have been in the interest of safety, at the present time when there is no occasion for any one to go between the cars when coupling, the dead blocks might again be used to advantage. They would prevent the coupler, with its moving parts, and the draft gear from receiving greater blows than they can be designed to withstand. Under present conditions the coupler receives the full force of all buffing blows, an unreasonable service to which primarily may be due many of the break-in-twos occurring to-day. By the use of dead blocks the force of all buffing shocks above the capacity of the draft gear, could be delivered to the car structure directly in line with the neutral axis of the center sills or sufficiently above the neutral axis to counteract the effect of the coupler load, due to the distance of its line of action below that point.

These paragraphs have touched on only a small number of the problems of the designer and outline but a few of the limitations within which he must work. They may be suggestive, however, of the almost numberless leads for study in car design. Possibilities are always ahead of the diligent student if he can only free his mind from consideration of what has been done and start on fresh lines of thought. The real problem of car design, after all, is the selection of the best possible compromise when all the limitations imposed by existing standards or economic and engineering conditions have been clearly defined and carefully weighed.

HANDLING MATERIAL FOR THE CAR DEPARTMENT*

BY R. A. DOHERTY
Storekeeper, Delaware, Lackawanna & Western, E. Buffalo, N. Y.

The primary object of a railroad, as we all know, is to transport commodities of every description. In order to do this with safety and with the least expense, the equipment must at all times be kept in proper condition, otherwise considerable revenue may be lost, due to the railroad not being able to handle the business on account of poor equipment, and additional expense will be incurred as transferloads after shipments have once been made may be necessary.

It is the duty of the car department to see that the proper repairs to cars are taken care of as quickly as possible and with the least expense, while it is the duty of the stores department to endeavor to be able at all times to furnish the material required. In the first place it should be the business of the storekeeper and his force to see that a proper stock of standard materials is on hand at all times; this should be taken care of by following up each day the condition of the stock and reporting such items as are running low, or which may be entirely out. In cases where the material is being hurried and is made in one of the company's own shops, the storekeeper at that point should be urged for prompt delivery. In this way by constantly following up the stock you will be able, as a rule, to take care of the needs of the repair department.

In ordering the materials, uncertain deliveries must be

* Abstract of a paper presented at the Niagara Frontier Car Men's Association.

taken into consideration as well as the monthly consumption of all items. It is getting to be a very difficult matter nowadays to follow up the question of deliveries on a great many items, and, due to this fact, it is necessary at times to order in heavy quantities, otherwise your orders will not receive the desired attention. The above applies principally to standard items of material. Whenever special items are required, which, as a rule, are not carried in stock, the car department should immediately notify the storekeeper just what materials are wanted, and when the cars they are wanted for are required to be put into service, so that a special effort may be made to obtain such items promptly. This is a very important feature and if it is given the proper attention by the supervising foremen it will often avoid cars being held out of service unnecessarily.

Co-operation between the car and stores department employees is very necessary. The railroad company in general benefits in the end if each individual employee will forget to draw the departmental line and realize that all departments will show the proper results at the end of each year if the principle of co-operation between departments is followed out in a consistent manner.

In order to minimize the expense of handling, material should be stored as closely as possible to the shops and repair yards, where it is intended to be used. All valuable material should, without question, be stored under cover, and in addition under lock and key. Employees in charge of the material should be thoroughly familiar with it, so as to avoid delays in delivery. All heavy materials, such as wheels, couplers, etc., should be stored outside at the most convenient points, where the work is done on them by the shops. It is just as important to carry the stock of new freight car wheels close to the mill building where they are bored and mounted and the freight car couplers close to the blacksmith shop in order to have pockets applied, as it is to carry the balance of the stock close to the repair yard.

The stock of lumber required should also be carried as close as possible to the shops in order to save expense in handling. The finished lumber should be kept under cover adjacent to the repair yards, if possible, while the rough lumber should be kept close to the mill building. All material should be stored as close as possible to the points where it is intended to be used and not stored as a matter of convenience to the stores department, taking into consideration, of course, facilities for handling and storing material.

A very important feature in connection with this subject is the use of reclaimed material. It should be used instead of new material in every case where it is possible to do so. This point cannot be impressed any too strongly on your employees. By making use of reclaimed, instead of new material, thousands of dollars can be saved annually. A great many employees have gotten the idea that once a casting or a bolt is removed from a car it cannot be used again. It is a well-known fact that a great many of such items which are daily removed from cars being repaired are just as good as new, or can be made as good as new with little expense, instead of being consigned to the scrap.

It should be the object of the car department of every railroad to see to it that responsible men who understand material thoroughly have supervision over what is known as material gangs, which gather up all material removed from cars. Such material should be examined thoroughly at that time and any items which can be used to advantage should be placed in the reclaimed stock and the balance delivered to the scrap docks. This is the time when it will pay to have the material examined and not wait until it has been delivered to the scrap docks, as it may mean a big saving to the company to have such material available for immediate use.

Due to the unprecedented advance in the cost of materials, particularly during the last three years, railroads today are facing a very serious and expensive situation in keeping the equipment in proper repair, and as I have just mentioned, it is the duty of every employee, regardless of department, to see that no new material is used where reclaimed material can be used instead.

Where shops have the facilities, it is now the practice to repair bolsters, couplers, axles, knuckles, etc., which were formerly scrapped. All bolts should be carefully sorted from the scrap, straightened, cut to the desired lengths, and re-threaded. All nuts can be assorted as to sizes and retapped, likewise all wrought iron washers can be reclaimed and assorted as to sizes. In fact, on every class of material handled, you will find a good portion of it can be reclaimed and made fit for use, instead of being sold for scrap.

There are two good points about this feature which it would pay us to remember; one is that a considerable saving is being effected in the use of reclaimed material and the other is that prompt repairs are being made to the cars by reason of using such material, whereas such work might be delayed considerably if sufficient new material was not on hand at the time. This reclaimed material question should be gone into thoroughly with the local inspectors at the outside inspection points, as well as foremen in the repair yards, as it is just as important to have this feature handled properly at these points as it is in the larger shops.

Our people handle this question in the following manner. All material required by local inspectors is ordered on our regular requisition forms once a month. These requisitions are forwarded to our general foreman, who turns them over to a competent material man, who in turn goes over each individual item very carefully and in every case possible, material from reclaimed stock is furnished before the requisitions are forwarded to the stores department for handling. I can assure you a good many dollars have been saved by this plan.

The accounting of material used is another important item which should be very carefully considered. The Interstate Commerce Commission Rules governing the classifying and accounting of materials cover this question thoroughly. In every large shop and repair yard the different foremen or clerks who have jurisdiction over the issuance of material tickets should endeavor to familiarize themselves with the standard rules of material accounting in order to see to it that all materials used are charged properly. This matter should be given very careful attention as the railroads are held strictly accountable for the proper distribution of material.

In closing, I would like to bring out two points very forcibly—the use of reclaimed materials and the co-operation of all employees to the end that all work required be done as promptly and as economically as possible. Each department head should instill in his subordinates the spirit of co-operation, and there is no question but that the railroad companies in general will greatly benefit in the end if this practice can be followed.

Railway Shop Employees' Part in the War.—The Railroads' War Board has had prepared and distributed 50,000 copies of a colored poster, the first of a series, addressed to railroad men, which will be placed in shops and other places where railway employees gather. The poster is illustrated with a large locomotive and train and an insert showing soldiers firing a large gun. The wording is as follows:

YOUR NATION'S NEEDS AND YOUR PART IN IT.

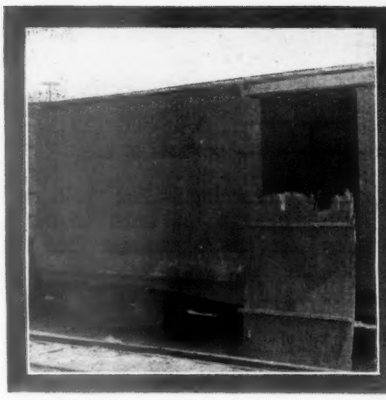
YOUR JOB DURING THE WAR IS TO CARRY THINGS WHERE THE COUNTRY NEEDS THEM.

WHAT GOOD IS A GUN, UNLESS YOU HAVE IT WHERE IT IS NEEDED? WHAT GOOD IS A GUN WITHOUT SHELLS—WITHOUT FOOD FOR THE MEN WHO FIRE IT?

YOUR SERVICES ARE ABSOLUTELY VITAL TO OUR COUNTRY'S SUCCESS IN WAR.

YOU ARE A RAILROAD MAN.

THE NATION IS COUNTING ON YOU.



Freight Car Maintenance

BY LEWIS K. SILLCOX*

STEADY progress in the efficient operation of large train units will be considerably governed by our ability to so provide and maintain old and new equipment that a reasonable margin of safety will obtain. The greatest problem today is the all-steel car and it will continue to remain so unless adequate facilities are provided to assure a proper program of shopping. It is simply a question of time until the greater part of a steel car must be replaced; renewals can only be economically and quickly carried out on a large scale for each car, for the reason that corrosion is more or less uniform throughout each section of the structure and one part cannot be disturbed without equally affecting the adjacent one. As steel cars advance towards the time of their periodical overhauling, many fail in service due to deterioration and care should be employed in selecting the worst cars in a series to be handled first, or it may be that prior to being taken into the shops, they can be used for company material, cinders or in the case of gondola cars, have solid wooden floors applied temporarily and assigned to lumber, cane, tie, brick or pipe loading.

Steel cars develop peculiar weaknesses, dependent considerably upon the service in which they are operated. It may be that side girders cause difficulty in buckling, which perhaps may be due to a weak center sill construction, or a light top chord or compression side girder member. Sometimes, but not often, side sills need reinforcement, or it may be that the end sills and draft members fail considerably. In any case it is generally conceded that replacement should be carried out in re-designed construction or such modification of the old that thoroughly good service in operation is assured. Hardly any expense less than $200 per car should be disregarded, if it is known that such expenditure will result in keeping the car away from the repair track the greatest amount of time between rebuilding periods, which extends anywhere from seven to twelve years.

Car Repair Costs.—Merely quantitative statements tending to reflect items such as average car repair costs, mileage per day, etc., for definite periods of time are only useful in a general way and in order to obtain a true idea of the actual cost of operation, it is necessary to determine the attitude in which the management of any road consider additions and betterments for instance, or write off depreciation. Sometimes many legitimate charges to capital account are allowed to remain under the heading of operating expenses unless due consideration is allowed for all accounting features affecting repair costs to equipment.

As a matter of interest repair costs on 28 prominent roads representing a total mileage of 119,857 and owning 1,119,-481 freight equipment cars revealed the fact that those lines spending the least amount of money obtained the least mileage from their cars. For instance, a road in the western classification territory spent $27.19 per car per year ending June 30, 1916, and the average mileage amounted to only 2,632 miles per car owned per year. On the other hand, another road in the same territory spent $79.30 per car per year during the same period and obtained 11,865 miles per car per year, or 32.5 miles per car per day, as compared to 7.21 miles per car per day in the previous case. The same relation, only not so marked, is true of roads in the Northwestern section of the country; here we find one road spending slightly less than $100 per car per year rendering a mileage of almost 13,000 miles per car owned per year; this as compared to an outlay of less than sixty dollars per car per year, but a mileage of only nine thousand on an adjacent line. The general tendency throughout the country can briefly be stated, that those roads spending the most on their equipment to keep it in good physical condition are able to realize a practical corresponding increase in mileage. The following gives the average cost of maintenance on 29 roads:

District.	Number of Roads Compared.	Total Cars Owned.	Average Mileage per Car Owned per Year.	Average Cost of Maintenance per Car per Year.
Pacific Coast	3	62,326	11,846	$74.91
Western	8	150,739	9,092	72.32
Northwestern	5	254,298	9,977	69.29
Central & Southern	6	162,936	9,345	87.47
Eastern	7	552,761	10,971	71.93
	29	1,183,060	10,246*	$75.18

* Equivalent to an average of 28 miles per car per day.

DRAFT GEAR

Unquestionably, no feature of car maintenance and construction has been so fully discussed as that surrounding the question of the draft gear and many hard problems are presented from the standpoint that a proper determination of the subject involves a compromise between theoretical and practical considerations,—neither can be neglected. Aside from any reference to a usual discussion, it might be interesting to devote attention along the lines that the average car itself, on account of being generally resilient, embodies a capacity for absorbing severe shocks, tentative analysis of which is given in the following broad examples and ought to be considered in the sense of practical rather than mere theoretical reasoning, as one familiar with switching movements in large terminal yards, often wonders why more damage does not result from rough handling than is actually experienced.

This necessitates a consideration of the mechanical factors involved, that is, what are the stresses set up and what energy is involved in the movement of cars approaching each other as in yard service or in train service, wherein the cars are coupled together? The following calculations are basic in their nature and in accordance with well known laws. For the purpose of illustrating, mathematically, the amount of energy which must be transmitted through the draft gear and car framing, we have fixed upon a maximum coupling velocity of 6 m. p. h., with a view of approaching what might

* Mechanical Engineer, Illinois Central.

be termed violent yard service. The equipment taken into consideration in these calculations are gondola cars and furniture cars.

The *energy* which must be transmitted through the draft gear in a moving car striking another standing car of same weight and *capacity* (this condition is selected as being the least destructive of any combination which might be considered), equals one-half the mass multiplied by the square of the velocity. This figure should be divided by 4 to obtain the value of the work which should be absorbed or dissipated through the draft gear and other resilient parts of the car, in view of the conditions laid down above. The application of the figures above mentioned develop the following results:

Empty Gondola Car.—

Conditions:
Light weight of car..... 41,000 lb.
Capacity of car.....110,000 lb.
Velocity of moving car.....6 m. p. h.

First, the energy (E) developed in the cars at the time they come in contact must be determined. As explained above this is equal to one-half the mass (M) multiplied by the square of the velocity (V). This figure should be divided by 4 to obtain the value of the energy which should be absorbed or dissipated in view of the conditions given above.

$$M = \frac{41{,}000}{32.2} = 1{,}272.67$$

$$V = \frac{6 \times 5{,}280}{60 \times 60} = 8.8 \text{ ft. per sec.}$$

$$E = \frac{\frac{M\ V^2}{2}}{4} = 12{,}317 \text{ ft. lb.}$$

The next step is to determine the amount of energy the sills are able to absorb (the cushioning effect) without being stressed beyond their elastic limit.

Conditions:
Area of sills (A).....31.08 sq. in.
Modulus of elasticity (E).....29,000,000
Elastic limit (L).....30,000 lb. per sq. in.
Truck centers (C).....372 in.

The elastic factor (e) of the sills is—

$$e = \frac{L \times C}{E} = \frac{30{,}000 \times 372}{29{,}000{,}000} = 0.38$$

The amount of energy these sills may absorb without exceeding their elastic limit is—

$$\frac{A \times L}{2} \times e = \frac{31.08 \times 30{,}000}{2} \times 0.38 = 177{,}156 \text{ in. lb., or } \frac{177{,}156}{12} = 14{,}763 \text{ ft. lb.}$$

Loaded Gondola Car.—The same procedure is followed in this case as before except the weight considered is 151,000 lb. instead of 41,000 lb. The energy (E), therefore, is—

$$E = \frac{\frac{M\ V^2}{2}}{4} = \frac{\frac{4{,}689 \times 77.44}{2}}{4} = 45{,}394 \text{ ft. lb.}$$

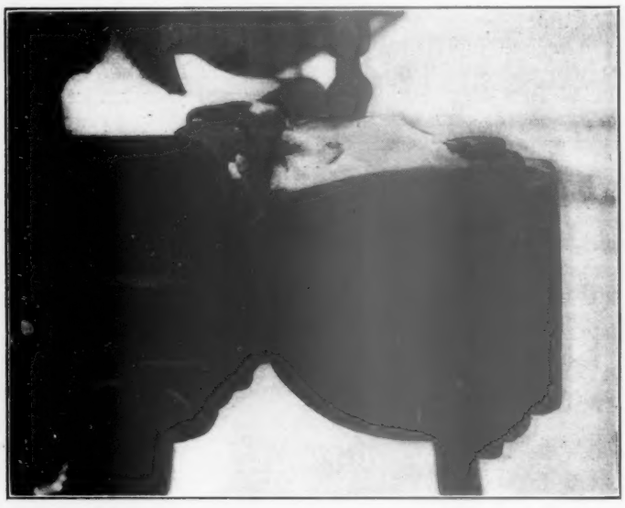
Since the sills are capable of absorbing 14,763 ft. lb., the remainder 45,394—14,763=30,631 ft. lb., must be transmitted or absorbed by other members of the car than the sill—preferably of course by the draft gear.

Furniture Car.—

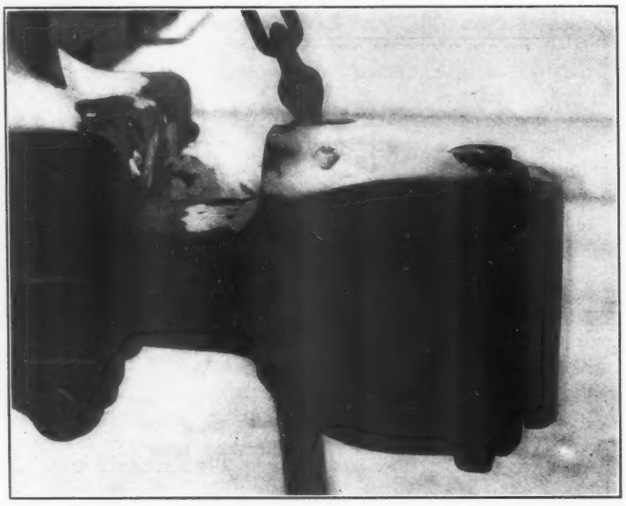
Conditions:
Light weight of car.....45,000 lb.
Capacity of car.....88,000 lb.
Velocity of moving car.....6 m. p. h.
Area of sills (A).....34.5 sq. in.
Modulus of elasticity (E).....29,000,000
Elastic limit (L).....30,000 lb. per sq. in.
Truck centers (C).....372 in.

By following the same procedure as outlined above the energy developed by the *light* furniture car is 13,532 ft. lb.

The amount of energy the sills may absorb without exceeding their elastic limit is 16,388 ft. lb.



View No. 1.—Showing the car with the coupler pushed back towards the striking casting.



View No. 2.—Showing the same car with the coupler pried out, denoting excessive slack which results from neglected maintenance.

An Example of a Poorly Maintained Draft Gear.

The amount of energy developed by the furniture car loaded to its capacity is 39,983 ft. lb.

The following table sums up all four cases and shows in addition the energy developed at 5 and 7 m. p. h.

Type of Car.	Conditions.	Weight in Lbs.	Energy in ft. lbs. to be Dissipated. At 5 Miles per Hr.	At 6 Miles per Hr.	At 7 Miles per Hr.
Gondola	Empty	41,000	8,575	12,317	16,769
Gondola	Loaded	151,000	31,600	45,394	61,800
Furniture	Empty	45,000	9,421	13,533	18,424
Furniture	Loaded	133,000	27,833	39,983	54,434

In this connection it is well to state that these loads are not capacities or stresses, but simply energy expressed in terms of "foot-pounds," which is force multiplied by distance, that is, one foot-pound would be the energy developed by one pound passing through one foot of space, or two pounds through half a foot (6″), or four pounds through one-quarter of a foot (3″).

Maintenance.—There seems to be a uniform misunderstanding regarding the maintenance of high capacity draft gears in general. When it is considered that we have a unit which is crowded into a very small space and designed to absorb in so far as possible the very worst shocks which service conditions impose upon it, any thinking person will appreciate that a certain amount of deterioration must re-

sult. With this thought as a foundation, is it not logical to assume that a penalty should be imposed upon the road which for any reason whatsoever offers a car in interchange with draft gears which have developed excessive lost motion; yet these conditions are experienced every day and result in break-in-twos on account of air brake hose parting or draft attachments failing on account of excessive slack action. It is simply a matter of deferred or neglected maintenance and if we are to obtain reasonable protection to equipment through the medium of a high capacity draft unit, we must be prepared to stand the expense for the work fulfilled. There is no use going about this important matter in a disinterested manner.

Draw Bar Yokes.—The matter of determining between the use of cast steel or wrought iron drawbar yokes is largely dependent upon the viewpoint taken. From actual tests covering a large number of samples, selected at random, it may be stated that the maximum holding power of a new genuine wrought iron yoke carefully gibbed and fitted over the butt of the coupler and secured in place by two 1¼ in. steel rivets, does not exceed 300,000 lb., the average being approximately 270,000 lb. On the other hand some roads require cast steel yokes to test out at 450,000 lb. when new and if under these conditions the construction employs the use of a gibbed design of pattern tending to relieve the coupler key from excessive strain, the full holding power of the yoke may probably be utilized in service with an ample factor of safety. The cross section, namely 5 in. by 1⅛ in. thick (5.64 sq. in.) of the M. C. B. standard coupler key,

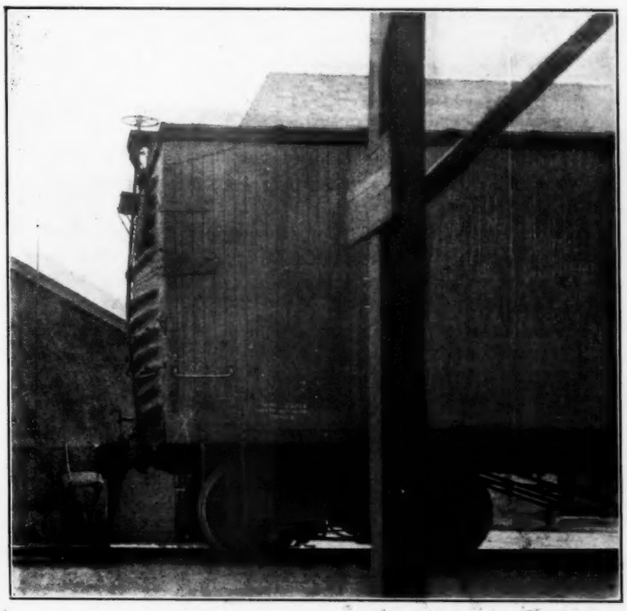
Failure Caused by Poor Loading.

Damage caused by a load of dressed timber loaded in an adjoining car and which was not bulkheaded.

makes it necessary to provide a material of high elastic limit, not less than 0.40 per cent. carbon steel, in order to resist excessive bending in service and, furthermore, coupler keys wear considerably in the slotted openings through the sills, unless carefully maintained. The wrought iron yoke, if properly applied, will generally give satisfaction, but so many cases of neglect in this respect has to a large extent discouraged its use in certain sections of the country. Improper design or installation of any type of a drawbar yoke is poor economy and dangerous in practice.

REINFORCEMENT OF HOUSE CARS

Sufficient emphasis does not seem to have been laid on the need of suitable end reinforcement for house cars. Only a small percentage of the roads are really providing designs which meet present-day requirements, either from the fact that they do not care that foreign roads are continually obliged to replace the original construction through combination, or because they have failed to compile figures showing the costs of repeated replacement of light construction, of a car with no reinforcement other than the common unreasonable delay to equipment and loss of lading resulting therefrom. The difference between the strength of the ends of a car with no reinforcement other than the common wooden end post with heavy end lining and one with the



Substantial End Saves Damage Claims.

This car was loaded with power house machinery and had not a substantial end reinforcement been provided, a damage claim of large proportions might have been experienced, certainly more than the expense of providing the steel end to the car.

same construction supplemented by two rolled steel Z-bars properly tied in place has been shown by actual test to be practically 100 per cent. This was obtained with an addition of only 500 lb. of metal per car.

TRUCKS

No car, if allowed to operate a sufficient length of time, will fail to develop patent defects in the truck side frames and bolsters. A truck frame or bolster which fails to give seven years' service, can be classed as being improperly designed. There is no real economy in reducing the weight of these parts to such an extent that their service life is directly affected. Just to maintain a so-called standard, it is hardly desirable to replace broken parts on obsolete types of trucks; it is a simple matter to provide the latest design and remove the old style, employing all the useful material in the maintenance for other trucks of like construction. From actual observance of results obtained in service, it is a question whether, in the interest of safety, it is a far-sighted policy to weld broken truck side frames and bolsters, as some of this work seems to be poorly done by those employing the practice and has resulted in very serious accidents.

BRAKE BEAMS

Another important feature that should be given careful attention concerns defective brake beams and parts. Pos-

sibly the largest percentage of the difficulty lies in the brake head, the brake hanger and the brake shoes. A great many cars are now in service with parts worn to such an extent that they are absolutely unsafe. Some roads give the attention required by these items, while others seem to disregard them entirely. Brake beams should be raised to properly inspect the heads, hangers and keys while the cars pass over repair tracks. A properly applied truck brake arrangement should guarantee uniform shoe wear, full release of the shoes when the brakes are not applied and the elimination of torsional strains tending to collapse the trussed type of brake beams.

AIR HOSE

Those roads operating through extremely cold climates give serious consideration to the matter of inspecting cars for serviceable and safe (non-porous) air brake hose. This element of caution could well be applied throughout the country and the number of break-in-twos, caused by bursted hose which generally result in disaster to car equipment, would be greatly reduced. For a single car or cut of cars with hose coupled together, it is only necessary to charge them with air in the usual manner, applying a standard coupling with the nipple end plugged to both ends of the car or cut of cars and open all angle cocks, then paint the hose with soap suds and remove any which show signs of porosity. If this practise were followed on all cars which are shopped or appear on the repair tracks, it would not be found to be a severe inconvenience.

A consideration of this matter would not be complete without deciding upon the probable life of air brake hose made in accordance with M. C. B. specifications and applied to equipment operating under normal weather conditions. Data carefully compiled along these lines, covering hundreds of samples selected at random as manufactured by four of the leading rubber companies for four prominent roads discloses the fact that the maximum life obtainable for any of the samples selected did not exceed 50 months' actual service, the minimum being about 24 months and the average less than 33 months, representing a service mileage of 409,860 miles per hose.

Weak Ends in Stock Cars.

Where stock cars are used for lumber loading, it is generally agreed that the posts should be securely braced, on account of the construction not admitting the application of heavy end lining such as is applied to other house cars.

RECLAMATION OF MATERIAL

To properly consider the reclaiming of material to be re-worked at a definite and known saving, would require too much detailed analysis and each branch of the work might be profitably considered separately; however, it is seldom that such items are dealt with satisfactorily in writing, as so much more can be gained from actual observation. Occasion is taken, however, to casually suggest a few of the items numbered among those generally followed throughout many sections of the country:

Re-rolling old truss rods into brake masts, column bolts, sill steps, flat bar iron for miscellaneous forgings.

Using arch-bar truck bottom tie straps to make brake beam safety supports, brake mast stirrups, reservoir supports, draft sill ties and old arch-bars to make coupler carrier irons, coupler horn braces for steel under-frames, side bearings and air brake levers.

Wooden Flat Cars Should Be Eliminated.

The wooden flat car for main line traffic is fast proving a failure and is frequently the cause of serious accidents in terminals, as well as damaging first class equipment adjoining it.

Old bolts can be straightened and pieced out to advantage under a Bradley hammer.

Worn brasses can be re-bored and lined, also bearing wedges and journal boxes can be reclaimed by building up the worn places by means of the welding torch.

Many cylinder packing leathers removed from service can be re-treated. That is, after all the dirt and other foreign matter is removed, they are re-filled and made non-porous in large quantities at reasonable cost.

Journal truing and wheel grinding machines of proper pattern are elements tending to guarantee extensive savings under certain conditions.

Door hasps for box and stock cars, pressed door handles, etc., can be made from good parts of old plates removed from steel cars.

Old tubes can be pounded out and made into split keys, washers, etc.

With the increased difficulty in obtaining suitable lumber, it is natural to consider the utilization, in so far as it can be economically done, of dismantled material. Old carlines and posts can be used as side door braces, old flooring, and for grain door nailing strips. Sheathing, if carefully removed, can be applied to work equipment and can be used for doors and as a lower course of roofing and lining in bunk and non-revenue cars. Short lengths of sills can be made into running board saddles, grain strips and cripples, and good parts of broken sills and serviceable sills from dismantled cars can be made into sill splices, if they are of the proper cross section.

Where fruit cars are required, it is generally economical to convert old equipment for this service.

In order to simplify the maintenance of a suitable stock of lumber on hand at all times, it is good practice to furnish a list of sizes covering the entire requirements for the system, a sample of which is shown below:

STANDARD SIZES OF CAR LUMBER—FREIGHT CARS.

End Sills

White oak, 7¼ in. by 8¼ in. by 10 ft.—caboose cars.
White oak, 7¼ in. by 9¼ in. by 9 ft. 6 in.—30-ton fruit and caboose cars.
White oak, 7¼ in. by 14¼ in. by 10 ft.—40 and 50 ft., 30-ton furniture cars.
White oak, 8¼ in. by 9¼ in. by 9 ft. 6 in.—40-ton box cars.

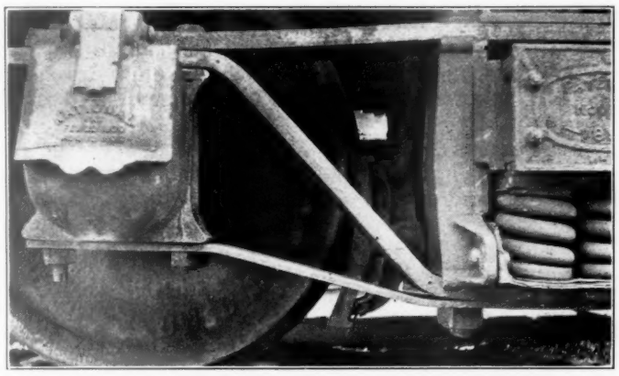
White oak, 8¼ in. by 12¼ in. by 10 ft.—40-ton gondolas and 40-ton flat cars.
White oak, 8¼ in. by 13¼ in. by 10 ft.—40 and 50-ton H. & B. side dump cars and 40-ton gondolas.
White oak. 9¼ in. by 13¼ in. by 10 ft.—40 and 50-ton Rodgers ballast cars.

These are, of course, in addition to the usual material specifications which include the standard contour for all classes of lumber.

PAINTING

With a view towards the systematic maintenance of freight equipment, several roads have adopted rigid instructions regarding the periodical painting of cars which has resulted in great benefit to all-steel equipment and metal roofs on house cars. Below is shown an extract from existing instructions employed by one of the largest roads:

"The following figures are given as a general guide in arriving at a plan of carrying on the painting of cars in order to cover the entire ground periodically.



Poorly Designed Truck Side Frame.

Deterioration of spring plank channels provides a substantial argument favoring the use of strong sections and not mere pressings of the lightest thin plate.

	Cars Owned and Leased.		Average Re-painting per		
Kind of Car.	All-Steel.	Wooden Box, etc.	5 Years.	Year.	Ratio.
House	.....	28,595	5,719	475	.42%
Gondola	11,582	13,751	5,066	422	.39
Refrigerator	.....	4,606	921	77	.07
Flat	.....	2,994	599	50	.04
Stock (owned	.....	1,230	246	21	.02
Stock (leased)	.....	371	74	6	.006
Caboose	.....	797	155	13	.01
Tank	10	.....	2	..	.004
Work	.....	2,852	570	50	.04

"This indicates that, based on a life of five years for each re-painting period, we would have to re-paint 1,114 cars per month. Out of every 10 cars re-painted, the ratio should be 5 house to 4 gondola to one of all other classes of cars."

Cars are stenciled when painted, in a suitable manner, showing the date painted and the shop at which the work was done.

GENERAL

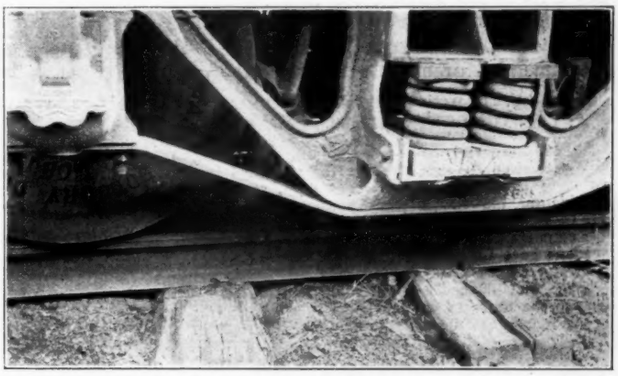
It is good business to repair cars and put them in serviceable condition when they are idle, having them ready for use when required, instead of having them held out or in service in a crippled condition. Good serviceable cars mean so much in reducing other expenses that there seems no reason why they should not be maintained in an efficient condition. A load placed in a defective car often means delayed movement, added expense in transportation, claims for demurrage and possibly dissatisfied patrons.

Undoubtedly the most economical repair costs may be obtained by the adherence to a policy of operating shops uniformly throughout the year, insuring the maximum yearly output with the minimum capital invested in buildings and equipment, permitting the retention of a steady trained force of workmen and insuring the best condition of rolling stock at all times.

The men who hold supervisory positions in the mechanical department are without exception loaded with a burden of cares and responsibility which leaves them little time for the study of long, intricate statements or reports. Columns of figures, no matter how skillfully arranged, give the salient facts only upon diligent study. This should encourage particular care being exercised in the preparation of periodical reports, cost statements and results of tests.

Wreck Reports.—A careful analysis of wreck reports is well worth the time spent. The following was developed from a twelve-month record of reports for one large road. The defects listed are exclusive of assigned responsibility for collisions, bad track, broken rails, improper loading, side swiping or rough handling, disregarding signals and they are shown in order of extent to which damage occurred: (1), axle failures; (2), truck side frame failures; (3), wheel failures; (4), draft gear giving away; (5), bursted piping and hose; (6), center plates and side bearings locked; (7), truck brake rigging down; (8), improper location of the side bearings; (9), loose wheels; (10), failures of the truck bolster.

Central Repair Points.—The general centralization of heavy car repair work at important terminals is by far of the greatest economy, provided adequate facilities are installed to handle the work with despatch. It is simply deplorable to observe the almost universal absence of suitable facilities to care for the maintenance of steel freight cars throughout the country, when with suitable arrangements cars could be passed through the shops in less than half the time it takes at present; this with a corresponding reduction in expense. Practically all car repair shops throughout the country are overburdened with repair work, because a much larger number of cars are in service and freight traffic has reached the highest point in the history of this country. There is a degree of efficiency necessary to keep a car reasonably safe for handling, and for the protection of the freight it carries. This efficiency must be such as to prolong its life at minimum cost. Greater uniformity in construction would insure a larger output at less cost, as suitable material would be more readily available and workmen becoming familiar with similar construction could perform the work with greater despatch.



Improperly Hung Brakes.

A typical example showing the importance of providing a properly designed brake arrangement. It is also to be noted that all nuts and bolts should be properly locked from turning or becoming detached.

Stores Department.—There is often a tendency on the part of the mechanical department to feel a lack of responsibility in the matter of keeping the general storekeeper fully advised in advance as to the requirements of the mechanical

department and also as to any necessity in its assisting to avoid an excessive accumulation of stock. Shortage of material is unavoidable under present market conditions, no matter how large or varied a stock is carried, but much of this can be prevented by keeping the division and general storekeeper fully advised as to the progress of the work for which material is needed. Every mechanical officer should consider it his duty to frequently make a thorough inspection of all material carried on hand for his department. As a rule the divisional mechanical officer who works in closest harmony with the division storekeeper is the one who least often is heard to complain about the shortage of material.

M. C. B. Letter Ballot Results

No. 2 Brake Beam Adopted as Recommended Practice with Modifications; Other Important Changes

At a meeting of the executive committee of the Master Car Builders' Association held in Chicago on June 14, 1917, a letter ballot containing 108 questions suggested by the various committees, was formulated to be submitted to the members of the Association. Of these 108 questions five were rejected by the members as follows: Specifications for journal box packing; the need for specifications covering freight car lubricants; the revision of section 41 in the specifications for lumber; the advancement of journal bearings for passenger and freight equipment to standards, and the revision of M. C. B. sheet U-11 regarding the pulleys, pulley seats and pulley keys for electric lighting equipment of passenger cars.

Following is an outline of the more important questions submitted to letter ballot which were accepted:

STANDARDS AND RECOMMENDED PRACTICE

It was voted to increase the over-all width of the bearings for 4¼-in. by 8-in. journals from 4⅛ in. to 4⅜ in., and on 5½-in. by 10-in. journals from 5¼ in. to 5⅜ in. in order to allow for the proper boring of the bearing, the present dimensions leaving too thin an edge after boring for a 5/16-in. lining metal.

The following items listed in the 1916 proceedings as recommended practices are advanced to standards:

Specifications covering dimensions and tolerances for solid wrought steel wheels for freight and passenger car service.
Minimum thickness for steel tires.
Wheel tread and flange for steel and steel tired wheels.
Wheel circumference measure for steel and steel tired wheels. (It was voted to have this measure cover steel, steel tired and cast wheels, thus eliminating the circumference measure for cast iron wheels shown on M. C. B. sheet 16-A.)
Rotundity gage for solid steel wheels
Plane gage for solid steel wheels.
Lining for outside-framed cars.
Sizes and dimensions for solid steel wheels. (It was also voted to change the name to wrought steel wheels.)
Truck side bearing clearance.

Limiting Dimensions for Pedestal Jaws for Cast Steel Truck Sides.—It was voted to change the limiting dimensions *B* for the 70-ton truck frame which are given on M. C. B. sheet 8 to the following:

Truck frame, maximum 5 15/16 in., minimum 5⅝ in.
Journal box, maximum 6 1/16 in., minimum 6 in.

LOADING RULES

Rule 9.—Rule 9 has been changed to read: "Lading on single cars must never project over the end sill of the car unless such overhang is protected by an idler or carrying car forming part of a group of cars. See Fig. 1." Note.—Fig. 1 and the first sentence of rule 10 has been changed to conform with the rule.

Rule 12.—The principal change in this rule was in the second sentence; it now reads: "(B) Hemlock or similar wood may be used only for the following loads: For single loads of stored lumber, rules 32, 33 and 34 (Figs. 5 and 6); for loading of tan bark, rules 60, 61, 62, 63 and 64 (Figs. 22 and 23); for loading of slab wood, rule 66; for lading of laths, rule 66a (Fig. 24) and for chocking and blocking for any load."

The paragraph *A* in the existing rule has been changed to paragraph *E* and now reads: "Gondola cars with sides 30 in. high and over may have the stakes placed on, inside of the car sides, either in or out of the pockets, providing the stakes rest on the car floor and are substantially wedged to the car sides by the lading."

Rule 13.—The sentence in the parenthesis in this rule has been changed to read as follows: "(Hemlock may only be used for single loads as provided for in rule 12, section B.)"

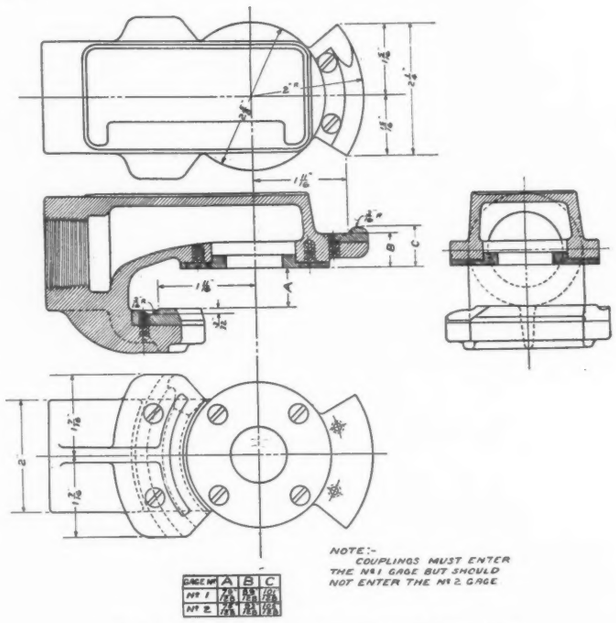


Fig. 1—Gage for Air Brake Hose Couplings

Rule 33.—In the first line after the word "equal," change the word "width" to "thickness" and after the word "side," in the eighth line, add the following: "Provided that strips will not be required if load does not extend more than 30 in. above the top of car sides."

Rule 34.—Section *D* is changed to read as follows: "For loads of lumber lapped or stripped in accordance with rule 33, size of hardwood stakes must not be less than:"

Rule 36.—The reference in the parenthesis in this rule has been changed from rule 34 to rule 13.)

Rule 58.—The second paragraph of this rule has been changed to read as follows: "When lading is in two piles

on flat or gondola cars and the ends of poles are interlaid at the center of the car as per Figs. 18, 19, 20 and 21, there must be not less than three pairs of stakes per pile, or six pairs of stakes for the total length of load." Figs. 18, 19, 20 and 21 are revised to conform to these changes.

Rule 67.—A note has been added to this rule reading as follows: "Sawed ties of more than 12 ft. in length may be loaded on flat cars, subject to the rules governing the loading of lumber on open cars.

"Hewn ties more than 12 ft. in length may be loaded on flat cars, subject to the rules governing the loading of logs, piling, props, telegraph and telephone poles."

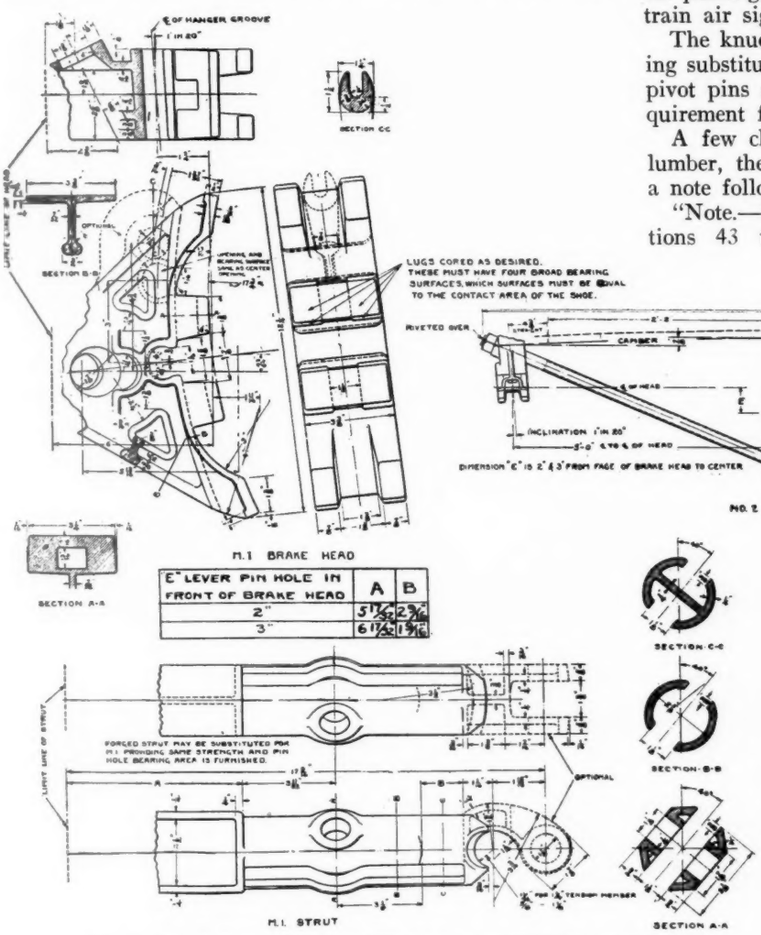

M.1 BRAKE HEAD
"E" LEVER PIN HOLE IN FRONT OF BRAKE HEAD
A
B
2"
3"
LUGS CORED AS DESIRED. THESE MUST HAVE FOUR BROAD BEARING SURFACES, WHICH SURFACES MUST BE EQUAL TO THE CONTACT AREA OF THE SHOE.
LIMIT LINE OF COMPRESSION MEMBER
RIVETED OVER
CAMBER
INCLINATION 1" IN 20"
DIMENSION "E" IS 2" & 3" FROM FACE OF BRAKE HEAD TO CENTER
NO. 2 BRAKE BEAM
U.S. STANDARD 7 THDS. PER INCH
ROD END DETAILS
FORGED STRUT MAY BE SUBSTITUTED FOR M.1 PROVIDING SAME STRENGTH AND PIN HOLE BEARING AREA IS FURNISHED.
OPTIONAL
M.1. STRUT
SECTION A-A
SECTION B-B
SECTION C-C

Fig. 2—No. 2 Brake Beam Adopted as Recommended Practice by the M. C. B. Association

Rule 81-*C*.—In the third line change the size of the top clamp from 2 in. by 4 in. to 4 in. by 6 in.

Rule 93.—The following note has been added to this rule: "The metal sliding plate used in connection with twin or triple loads of flexible material should be greased at interchange points to facilitate the curving of the cars."

Rule 124.—A paragraph has been added to this rule as follows: "Lading in vehicle cars with end doors must be securely protected against end shifting and loaded in such a manner that the lading will not come in contact with the end or side doors."

TRAIN BRAKE AND SIGNAL EQUIPMENT

It was voted to change the rules covering the adjustment of piston travel to read as follows: "Piston travel should be adjusted to not less than 6 in. nor more than 8 in."

The gage for air brake hose couplings shown in Fig. 1 was adopted as recommended practice.

The K-1 triple valve for 8-in. and the K-2 triple valve for 10-in. air brake equipment were advanced to standards.

SPECIFICATIONS

The specifications for the following material were adopted as recommended practice: Black paint; elliptical springs; insulation paper for refrigerator cars.

The paragraph regarding "deflection test" was added to section 4 of the specifications for air brake hose gaskets. The specifications for helical springs were rewritten. A slight change was made in the specifications for steam heat hose for passenger equipment cars, steel axles, and air brake and train air signal hose.

The knuckle pivot pin specifications were eliminated, being substituted by the specifications for heat-treated knuckle pivot pins and these were advanced to standard. The requirement for silicon was omitted from these specifications.

A few changes were also made in the specifications for lumber, the most important of which was the addition of a note following section 42, as follows:

"Note.—For material furnished in accordance with sections 43 to 47, the following 'Density Rule' may be applied where so specified by the purchaser:

"(A) Dense southern yellow pine shall show on either end an average of at least six annual rings per inch and at least one-third summer wood, all as measured over the third, fourth and fifth inches on a radical line from the pith. Wide-ringed material excluded by this rule will be acceptable, provided that the amount of summer wood as above measured shall be at least one-half.

"The contrast in color between summer wood and spring wood shall be sharp and the summer wood shall be dark in color, except in pieces having considerably above the minimum requirement for summer wood.

"(B) Sound southern yellow pine shall include pieces of southern pine without any ring or summer-wood requirement."

The following specifications were advanced from recommended practice to standards:

Carbon Steel Bars for Railway Springs.
Rivet Steel in Rivets for Passenger and Freight Equipment Cars.
Mild Steel Bars for Passenger and Freight Equipment Cars.
Chains.
Cement for Mounting Air Brake Hose.
Galvanized Sheets for Passenger and Freight Equipment Cars.
Structural Steel, Steel Plates and Steel Sheets for Passenger Equipment Cars.
Structural Steel, Steel Plates and Steel Sheets for Freight Equipment Cars.
Welded Pipe.

BRAKE BEAM AND BRAKE SHOE EQUIPMENT

It was voted to adopt as recommended practice a strut, strut lever and lever pin connection for brake beam and lever of 1 3/32 in. in diameter by 3½ in. under the head; a brake

beam hanger pin of 1¼ in. in diameter by 7 in. under the head, and a brake beam hanger diameter of 1 in.

No. 2 Brake Beam.—The brake beam committee succeeded in designing a No. 2 brake beam which, with certain limitations, has been accepted by the association as recommended practice on a close vote, 1,425 voting in favor of it, 673 against it, with 1,399 votes necessary for adoption. This has been accepted with the understanding that a future report will be made on the compression member and its attachment to the head and strut members. The beam is shown with its details in Fig. 2. It is further understood that this beam is adopted only as a progress design, as the final requirements have not been worked out by the committee. No third point suspension is shown. It is optional in providing a 1⅛-in. opening at the end of the strut casting for supporting this portion of the beam by any means desired by any road, but that is not compulsory in the construction. A tabulation of the malleable brake heads which are being put on beams developed the fact that they weigh all the way from 6½ lb. to 21 lb. apiece. In the first case the shoe

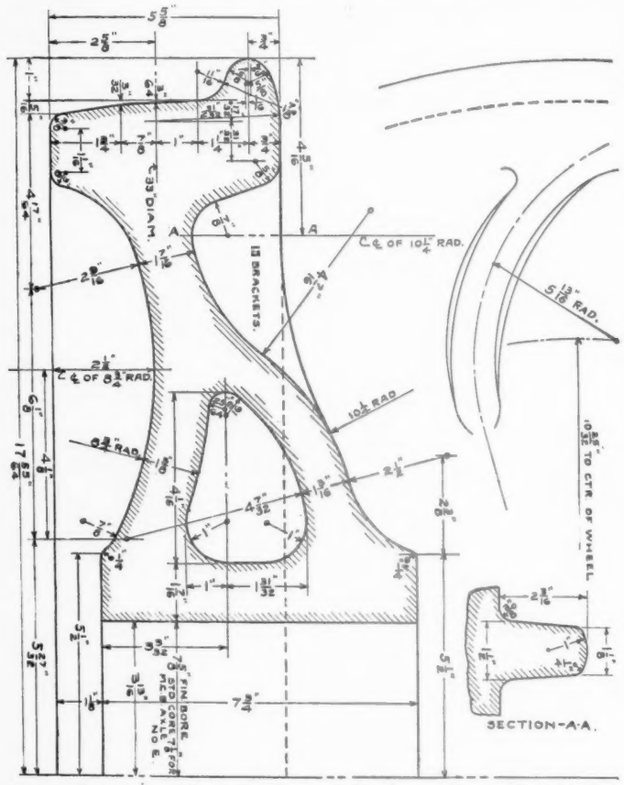


Fig. 3—Cast-Iron Wheel for Cars of Maximum Gross Weight Not to Exceed 210,000 lb.

cracks and works out, and in the second case an unnecessary amount of malleable iron is being purchased. In the design of the brake head, the pot-hook opening is shown at the center as the committee feels that the center hanging is correct. However, an optional location shown by dotted lines in Fig. 2 for the pot-hook opening at the upper end of the head is permitted.

The specifications and tests of brake beams were revised.

CAR WHEELS

The 33-in. cast iron wheel shown in Fig. 3 was adopted as recommended practice for cars of maximum gross weight not to exceed 210,000 lb.

The 33-in., 700-lb. cast iron wheel shown in Fig. 4 was adopted as recommended practice in place of the present 675-lb. wheel of the same diameter.

It was voted to change the condemning limits for worn thin and worn vertical flanges of cast steel wheels to 15/16 in. when worn thin and 1 in. when worn vertical, which is the same as for wrought steel wheels.

An additional paragraph was added under the heading "mounting wheels," in the specifications for 33-in. cast iron wheels, as follows: "The wheel face on all axles must be turned to a uniform diameter throughout the entire length of each wheel fit and must be smooth and free from ridges, so as to provide an even bearing for the wheel fit throughout.

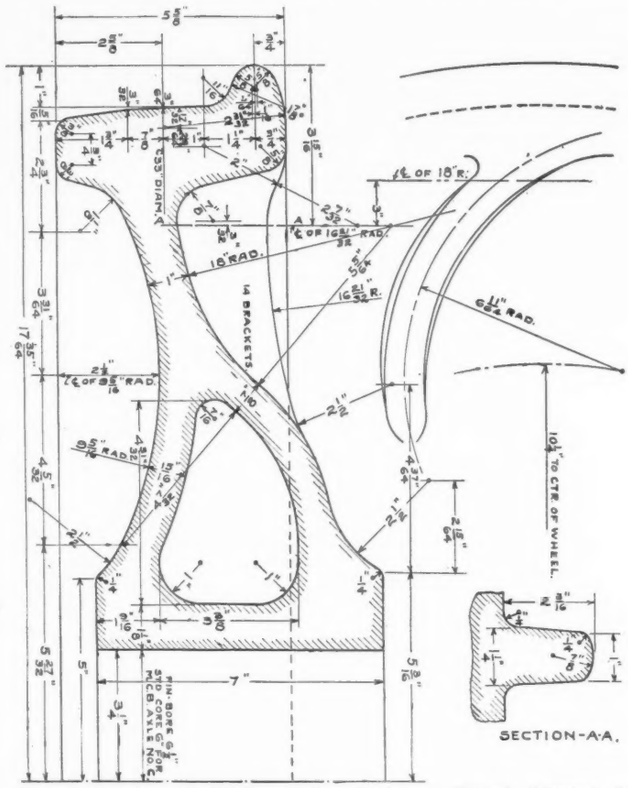


Fig. 4—Section of 700-lb., 33-in. Cast-Iron Wheel Adopted to Replace the 675-lb. Wheel.

Mounting wheels on axles having the wheel fit tapered is not permissible."

TRAIN LIGHTING AND EQUIPMENT

The following paragraphs of the specifications for electric lighting of passenger equipment cars were advanced from recommended practices to standards:

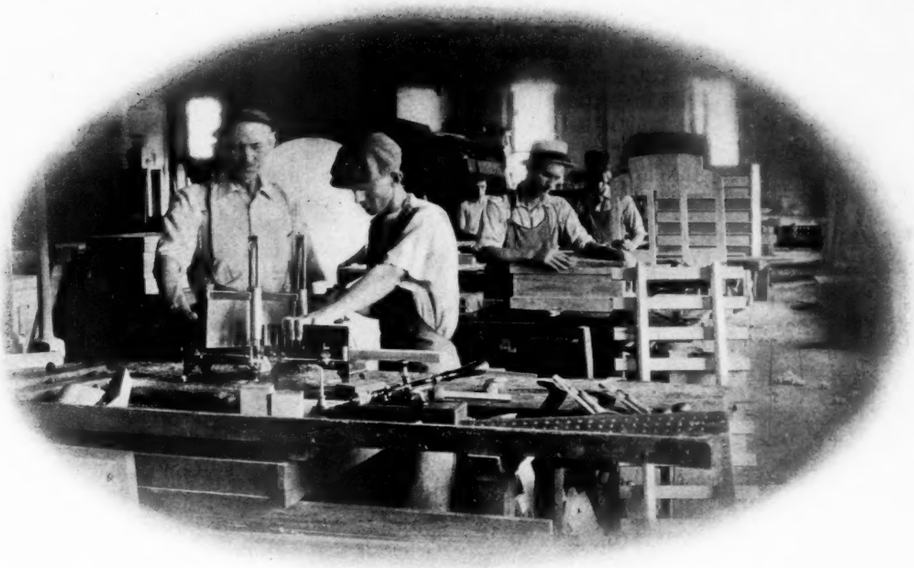
Paragraph 1. (System voltages.)
Paragraph 5. (Mounting.)
Paragraph 6. (Axle pulley and bushings.)
Paragraph 9. (Size of ball bearings.)
Paragraph 10. (Boxes, design.)
Paragraph 12. (Dimensions of battery trays.)
Paragraph 13. (Connections.)
Paragraph 14. (Charging receptacles.)
Paragraph 16. (Terminals.)
Paragraph 19. (Switchboards.)
Paragraph 20. (Fuses.)
Paragraph 21. (Installation of conduit and wire.)

TANK CARS

A number of changes were made in the specifications for tank cars, most of which are minor in character and as a rule do not change the substance of the present requirements. The following are the principal changes: Item 23 in the class I and class II specifications was changed to permit the restricted use of cars tested to 40 lb. after January 1, 1918.

In the specifications for the class III and the class IV tank cars item 9, paragraph 3 has been changed so that malleable iron for striking plates and draft lugs is optional.

A new set of specifications called "Class V, Tank Car" was adopted for the use of chlorine and sulphur dioxide.



Instructing an Apprentice in the Cabinet Shop.

FREIGHT CAR APPRENTICES ON THE SANTA FE

Difficulties Encountered in Securing Recruits and Successfully Training Them Gradually Being Overcome

THE Atchison, Topeka & Santa Fe has had exceptionally good results in its attempts to provide an adequate apprenticeship course for its freight car apprentices. That part of the proceedings of its ninth annual apprentice instructors' conference referring to this class of apprentices, an abstract of which follows, is therefore of more than ordinary interest. A similar account of the proceedings of the eighth annual conference was published in the *Railway Mechanical Engineer* of August, 1916, page 403. That the importance of making a decided effort to select and train young men for this work is becoming more generally recognized is indicated by the large competition on this subject which was held last year under the direction of the Chief Interchange Car Foremen's Association. The prize article was printed in the November, 1916, issue of the *Railway Mechanical Engineer,* page 579. The second prize was awarded to C. N. Swanson, superintendent car shops of the Santa Fe, Topeka, Kan. It was printed in the December, 1916, issue of the *Railway Mechanical Engineer,* page 639, and gives an excellent outline of the courses of training which are provided for car department apprentices on the Santa Fe. The more important parts brought out at the recent conference follow:

WHAT IS NEEDED IN THE FREIGHT CAR SHOP?

O. D. Buzzell, general foreman, car department, San Bernardino, Cal., spoke on this subject as follows:

In addition to teaching the boys carpenter work they should also be given a thorough training on airbrake equipment. The Interstate Commerce Commission requirements are very strict regarding the airbrake equipment. Furthermore, if these men are made familiar with air work, it will serve to retain more of them in service, as they will be able to command a better rate of pay, and be eligible for further advancement as inspectors. Our apprenticeship system is the best method known for training men in air brake equipment.

The highest class of car work is given the apprentices at San Bernardino, including the reconstruction of cars. After a boy is far enough along the car carpenters are glad to have them work with them. Start the boys on truck work. As this is the foundation of the car, it should also be the foundation, or first work of the apprentices. During the course they should be given an opportunity to see how every part of a car is constructed.

Mr. Buzzell commented on the rapid change from the wood freight car to the steel car, and emphasized the importance of giving the apprentices a thorough training on steel work. As long as we have refrigerator cars there will always be more or less wood work, but the trend is toward the use of the steel car, and it is up to us to prepare for this need.

Discussion.—It is important that the instructors take an interest in the work of the boys and in the personal life of the boys, and they should be encouraged to save.

The latter point was emphasized by S. L. Bean, mechanical superintendent, who also mentioned the importance of helping to develop the young man's character, and doing all possible to keep him out of bad company.

The school hours of the boys of this trade were also discussed; it was the consensus of opinion that instead of having two hours of school twice a month, they should be allowed to attend school as often as apprentices of other trades, that is, two hours a week, if it is possible. The school should be held in the morning hours rather than in the afternoon.

INSPECTION WORK—HOW HANDLED.

In teaching the apprentices inspection, it was thought best to teach them the minor defects first, and later the com-

plex defects. When an apprentice is on any particular class of work, the principal or common defects arising therein should be explained. This should be carried out throughout the entire apprenticeship. The instructor should go with the boys and actually make an inspection trip over a train of cars. The boys should be taught to live up to the M. C. B. rules explicitly. It was agreed by all that the inspection work should be given the apprentices toward the last six-months' period of their course.

TEACHING M. C. B. RULES

In order that the apprentices may fully understand these rules, it is best to have the school instructor teach the boys the rules in the school room; this to be followed up by the work of the shop instructor. The shop instructor, wherever possible, should give the boys work on foreign cars, where they may have a better opportunity of explaining the rules to the apprentices.

The subject of teaching the apprentices the manner of billing for repairs on freight cars was also discussed. It was suggested that the local instructors arrange for the M. C. B. clerk, or travelling car clerk, to visit the school room occasionally and give instructions to the freight car carpenter apprentices regarding the bills to be made out incident to repairing foreign cars.

METHOD OF SECURING APPLICANTS

It was pointed out that applicants for this trade were very hard to secure, particularly so in some localities. The general opinion seemed to be that the best applicants had been secured from labor gangs in the shops or car yards, from sons of employees, or from friends of other apprentices. Many good boys have been obtained from nearby towns, and often have made application as a result of baseball games in these localities. It was suggested that when one of these boys from a nearby town went on a vacation the instructor should make it a point to speak to him about his work, and in wishing him a good time on his trip should suggest that if there were any other good boys in his home town who would care to serve an apprenticeship in the car shops, to have them make application. In this way, many good boys have been obtained. When a prospective applicant calls upon the shop instructor, the latter should make it a point to show him thoroughly what work the apprentices in this trade are given, and what the opportunities are for advancement.

In addition to the difficulty of securing good applicants for apprenticeship in this trade, still greater difficulty was reported in holding the young men during the first six months' period. The boys are older than the apprentices in other trades, most of them being 20 to 24 years of age. Since many of them are married, they have great difficulty in pulling through, with the wages being paid at present. It was agreed by all the instructors that if a higher rate of pay was given during this period it would be of material help in holding these boys.

It was urged, too, that a greater variety of work should be given the apprentices during the first six months to keep them interested in their work and let them know that they are actually learning a trade and would later receive greater benefits. It was urged also that the instructor enter thoroughly into the home life of the boys, and make them feel that he is their friend. In connection with the question of humane treatment and kindness that should be accorded the apprentices, the following poem was recited:

If with pleasure you are viewing any work a man is doing,
If he's worthy of the comment, tell him now.
Don't withhold your approbation till the parson makes oration,
And he lies with snowy lilies o'er his brow;
For then, no matter how you shout it, he won't really care about it,
He won't know how many teardrops you have shed—
If you think the praise is due him, now's the time to slip it to him,
For he cannot read his tombstone when he's dead.

More than fame and more than money, is the comment kind and sunny,
And the hearty warm approval of a friend;
For it gives to life a savor, and it makes you stronger, braver,
And it gives him heart and spirit to the end.
If he earns your praise, bestow it; if you like him let him know it.
Let the words of true encouragement be said.
Do not wait till life is over and he's underneath the clover,
For he cannot read his tombstone when he's dead.

SCHEDULE OF WORK

It is best to start the boy out on truck work, as far as possible, and have the inspection work given him last. In general, the schedule adopted at the last meeting (*Railway Mechanical Engineer,* August, 1916, page 404) has been found very satisfactory, though, of course, it will have to be varied according to the location.

INSTRUCTORS CO-OPERATE

The school instructor can assist the shop instructor in teaching M. C. B. rules; also in helping the boys on air work with the charts in the school room. From charts showing the anatomy of freight cars, flat cars, etc., he can give the apprentice much instruction that will assist the shop instructor in teaching the work of this trade. He can also assist in teaching safety appliances and should train the boys in sketching and drawing.

The freight car shop instructors introduced a resolution stating that they believed it would be a great benefit to both the shop instructors and the apprentices if they could have blue prints showing classes and series of freight cars, these to be filed in a convenient place for the use of the apprentices. They have experienced much trouble because of not having access to prints. Standard prints are just as essential in the car shop as in the locomotive shop, and a series of prints should be worked out and made available for the use of the apprentice boys.

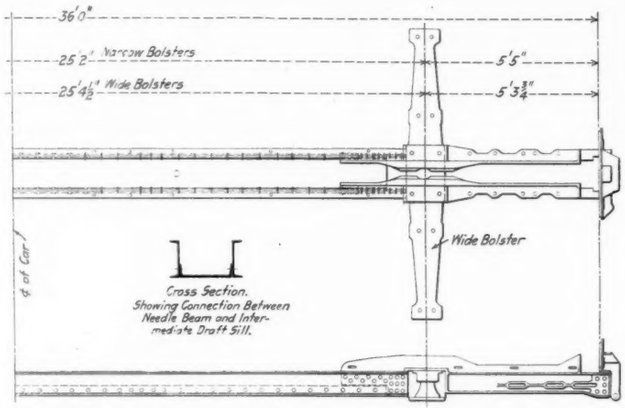
UNIQUE UNDERFRAME REINFORCEMENT

For several years the Marsh Refrigerator Service Company, Milwaukee, Wis., has been building steel underframes which have been applied both to new cars and to old cars requiring reinforcement of the draft members. A new design has recently been adopted by this company which is of interest because of several novel features, the most important being the arrangement for making use of the bolsters removed from rebuilt cars in connection with the new underframe.

The underframe formerly used was built up of two 9 in. 20-lb. channels extending the entire distance between the end sills and reinforced in the center section by a 13 in. 32-lb. separator channel. The body bolsters were steel castings with cored holes through which the center sill channel passed. Heavy cast steel striking blocks were used. The center of the car was carried on needle beams of channel section, attached to the center sills and further supported by four truss rods.

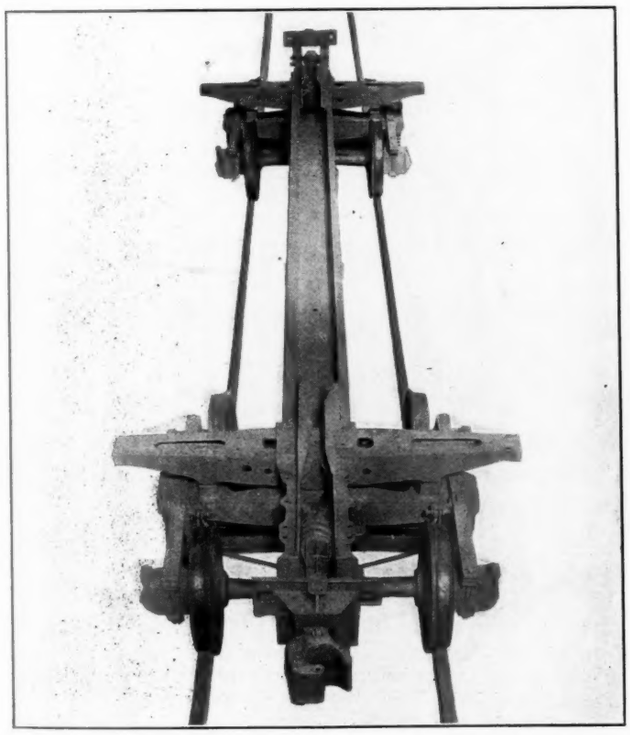
In order to do away with the necessity of providing new body bolsters when reinforcing cars, the design of the underframe has been modified. The center sill cross

section has not been changed, but the channels, instead of extending the full length of the car, are brought only to the bolsters. Economy draft arms of special design, fitting over the bolsters and securely riveted to the center sill



Half Section of the Underframe Used by the Marsh Refrigerator Service Company

channels, form the center members at both ends of the car. The draft arms are made to accommodate Farlow draft gear with 8 in. by 8 in. springs. Cast steel striking plates similar to those used on the original design are riveted to the draft arms; thus, the end sill is held securely between the lug on the draft arm and the striking casting. Two of the truss rods pass through the striking casting and over

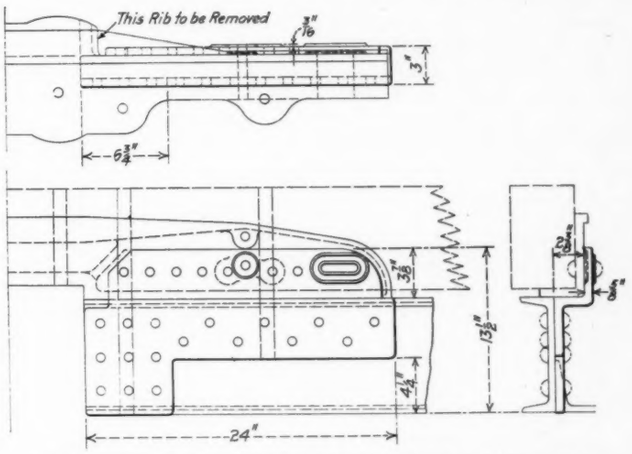


Underframe Ready for Application of Car Body

saddles at the bolsters, furnishing additional support for the outer ends of the draft arms. A change in the needle beam has also been made in this design. It was found that in case a car was knocked off center considerable damage was often done to the wooden sills by the metal needle beams. It was therefore considered best to return to the use of wood for these members.

In building wooden refrigerator cars to be used with steel underframes, the sizes of the wooden sills are not reduced. It has been found advantageous to have the car bodies sufficiently rigid to do away with the necessity of supporting them at a large number of points when they are raised off the underframe. In the present design side sills of 5 in. by 10 in. section have been used with 5 in. by 9 in. intermediate sills and 5 in. by 8 in. center sills.

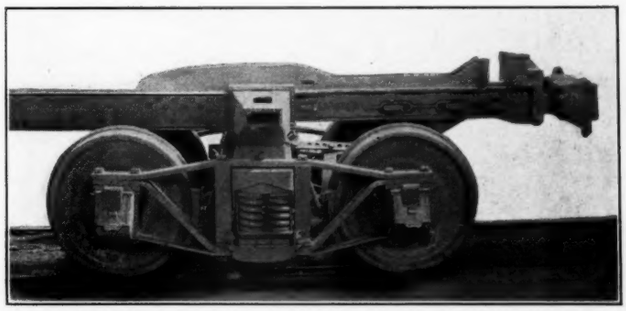
In designing the new underframe it was desired to make it applicable to cars of two different series, one having a body bolster 14 in. wide while the bolsters on the other series were 11½ in. wide. In order to accommodate both bolsters the underframe was designed with a 14 in. bolster



ADAPTER CASTING USED ON ECONOMY DRAFT ARM

opening. When applying underframes to cars with 11½ in. bolsters a 2½ in. filler casting is welded to the bolster.

Some of the cars now being reinforced with steel underframes have been equipped with the Economy draft arm applied to the wooden sills. In order to save the draft arm a casting was designed to be attached to the section of the



View Showing Construction at End of Underframe

draft arm which extends beyond the bolster, joining it with the center sills in the same manner as in the case where the special design of draft arm is used.

THE FIRST SUBMARINE.—The first submarine boat of which history makes any record was built by a Dutchman, named van Driebel, in 1640. The boat was built in England with money said to have been advanced by King James I. According to reports the vessel had a unique ballasting system. There was a number of goatskin bags placed under the deck between two large planks. These bags, when filled with water, caused the vessel to sink. To cause it to rise again the bags were pressed together again with a windlass arrangement, forcing the water out, and thus giving the boat reserve buoyancy.—*The Engineer.*

TANK CARS FOR THE SANTA FE

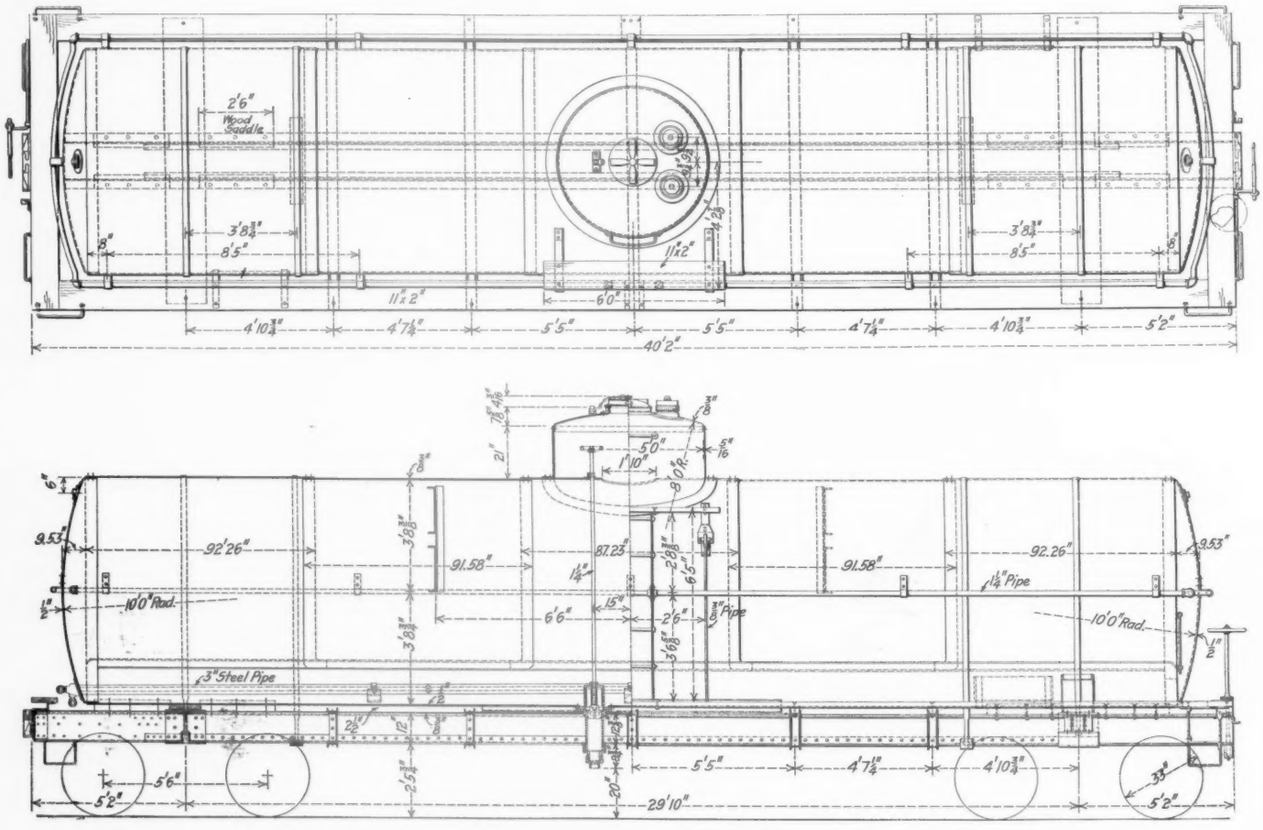
Constructed in Accordance with the Latest M. C. B. Class III Specifications, of 12,000 Gal. Capacity

THE Santa Fe has ordered from the Pressed Steel Car Company, 500 tank cars of 12,000 gal. capacity, which are to be used largely in the company's service for handling fuel oil. These cars were designed by the railroad in accordance with M. C. B. specifications for class III tank cars as revised in 1916.

The barrel of the tank is of open hearth steel plate, the bottom being a continuous plate ½ in. thick and 83 in. wide. The upper part of the barrel is in five sections of ⅜ in. plate. The heads are ½ in. thick and are dished to a radius of 10 ft. The dome is 5 ft. in diameter inside and is made of 5/16 in. plate on the sides and ⅜ in. on the top. The dome cover is dished to a radius of 8 ft. The dome ring is of cast steel and the dome cover of malleable iron. The cover has the usual outlets just below the flange to allow any pressure confined in the tank to escape before the cover is removed. There is a special lead gasket provided on the lower side of the flange of the tank cover and four holes spaced at 90 deg. are cored in the top so that pipes may be inserted to facilitate the application and removal of the cover.

One of the unique features of the construction is the application of splash plates to prevent an unequal distribution of weight on the trucks during brake applications. Two of these splash plates are provided, one on each side of the center of the tank and 6 ft. 6 in. from the center. They consist of two sections of 5/16 in. plate, each 18 in. wide, the upper plate placed 3 in. from the inside of the top of the tank shell and with a 5⅜ in. space between the upper and lower plates. They are secured to the shell by 5/16 in. gusset plates. The bottom outlet valve casing is of the usual type except that it has an internal thread above the valve seat into which a casting is fitted which serves as a valve rod guide and also prevents foreign substances from getting under the valve seat. The safety valves are two in number of the latest M. C. B. standard type attached to the top of the dome and set to open at a pressure of 25 lb. per sq. in.

An ingenious method of fastening has been used on the handholds at the ends of the tank. In order that the handholds may be replaced from the outside they are attached with a special stud. The section is such that breakage is most apt to occur outside the hexagonal portion of the stud, in which case it can be readily removed with a wrench. In case the stud is broken flush with the tank it can be drilled out and replaced from the outside.

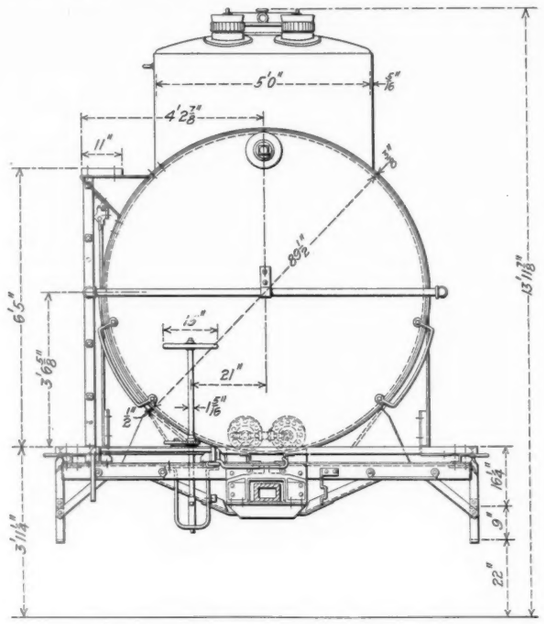


Santa Fe Tank Car Built in Accordance with the New M. C. B. Specifications

As the vapor given off by fuel oil is poisonous, the cars must be steamed out before it is safe for a workman to enter them to make repairs.

In one end of the tank near the top a 4-in. pipe flange and plug are provided to facilitate washing out the tank. The heater pipes are arranged according to the Vapor Car Heating Company's system. Two flanged couplings are provided at one end of the car. The main steampipes, 3 in. in diameter, are screwed into these castings and extend along the

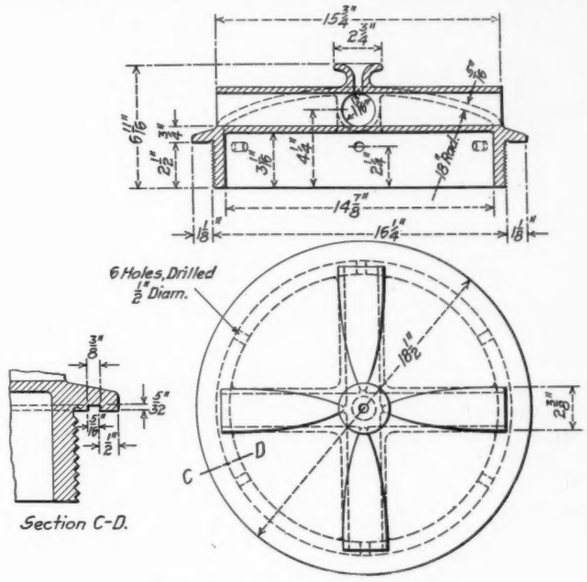
bottom of the tank for nearly the entire length, being closed at the end with a pipe cap. Inside each of the 3-in. pipes is a 1-in. pipe held in position by star couplings. The end



End View of the Santa Fe Tank Car.

castings are joined by slip joints and the steam pipes lead to a trap under the tank.

The underframe is designed principally to resist buffing stresses since the tank is largely supported at the bolsters. The center sill is made up of two 12-in. 35-lb. ship channels spaced 14¼ in. back to back, reinforced on the top by a ⅜-in. cover plate 22 in. wide extending the full length of the car and at the bottom by two 3½ in. by 2½ in. by ½ in. angles, extending 16 in. beyond the centers of the bolsters. Five stiffeners of pressed steel are located between the channels. The body bolsters are of built-up construction with a cast steel center filler and ⅜ in. pressed steel side diaphragms spaced 5 in. back to back and reinforced on top and bottom by ½ in. steel plates 16 in. wide. On top of the bolsters are cradles built up of 5/16 in. plate. Wooden blocks fitted into these cradles support the tank at each end.

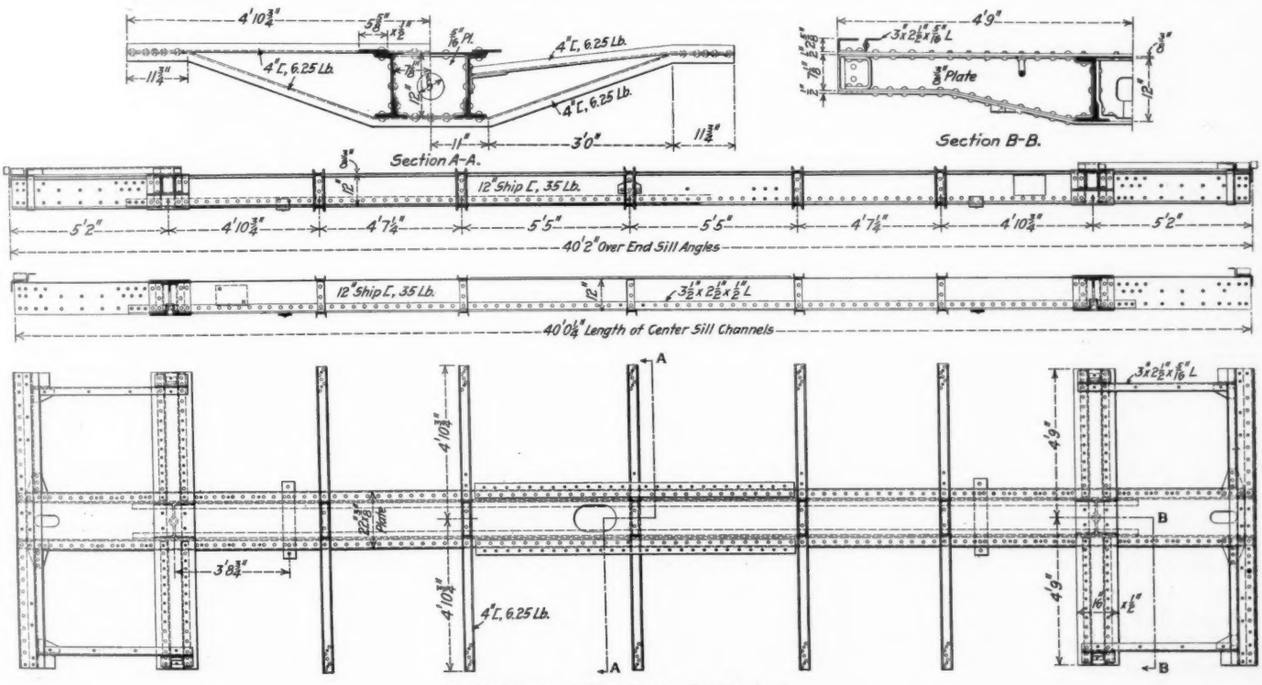


Dome Cover for Oil Tank Car

Push pole pockets are riveted to each end of the bolsters on the side nearest to the end of the car.

The end sills are built up of 4 in. by 4 in. by ½ in. steel angles reinforced on top by a Z-shaped cover plate 5/16 in. thick. The ends of the end sills are supported by 3 in. by 2½ in. by 5/16 in. angles connected to the bottom flange of the center sill channel.

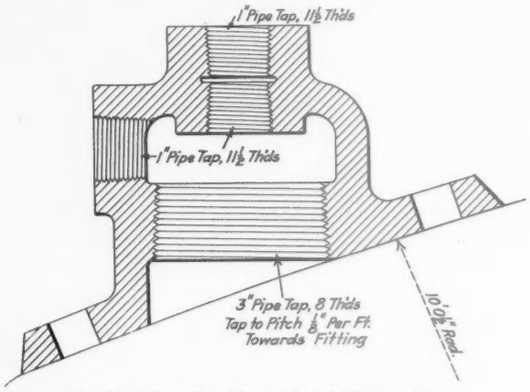
The tank is secured against end shifting by anchors 10 ft. long of ½ in. pressed steel. These are secured to the bottom



Underframe of the Santa Fe Tank Car.

of the tank with ¾ in. rivets and are fastened with 1 in. bolts of double refined iron to anchor supporting plates 5⅝ in. wide, ½ in. thick and 10 ft. 4 in. long.

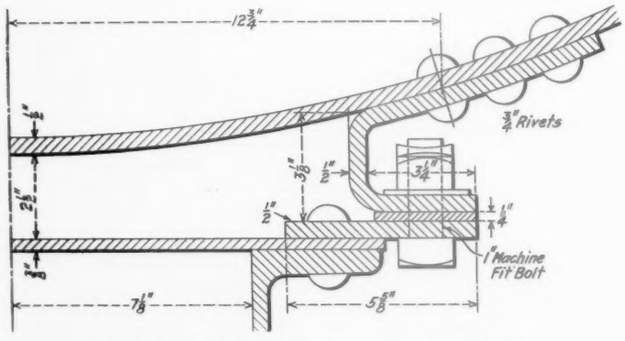
The end running boards are supported by the end sill cover plates by Z-shaped brackets of ¼-in. plate. The side running boards are supported between the end sill and the body bolster by 3-in. by 2½-in. by 5/16-in. angles. Between the bolsters four supports are provided which are



Casting for the Steam Heat Connection.

formed of 4-in., 6¼-lb. channels placed back to back under the running board and riveted together, one running over the top and one under the bottom of the center sills, to which they are also riveted.

The draft gear is of the friction type Miner class A-18-R. The draft lugs are of cast steel, the front and rear lugs on each side forming an integral casting. The coupler yokes are of open hearth steel, 5½ in. by 1½ in., fastened to the couplers with rivets of double refined iron. The couplers have 5-in. by 7-in. shanks and 9⅛-in. butts. The coupler



Method of Attaching the Tank to the Frame.

is supported by a carrier wearing casting placed on the carrier iron which furnishes a large bearing surface and reduces the wear on the coupler.

The trucks are of the Andrews cast steel side frame type with cast steel truck bolsters equipped with Barber roller lateral motion device. Cast iron wheels and malleable iron journal boxes are used. Among other specialties are Westinghouse brakes, Simplex couplers, Creco brake beams, National malleable journal boxes and the Imperial uncoupling arrangement.

THE VALUE OF MECHANICAL ENGINEERING.—Nowadays most of the civil engineer's work is done by machinery. The mechanical engineer is called in at the inception of every big undertaking, whether civil or military; and those not thoroughly grounded in mechanics have to take a back seat. —*Railway Gazette, London.*

STRESSES ON END FRAMING OF CARS

BY H. J. HENNESSEY

Calculations covering the stresses on end framing of cars by the action of the lading when abrupt changes in the speed are encountered, have been very vague or unreliable. The following method is submitted for consideration:

Maximum buffing shock which the car will sustain (freight 150,000, passenger 300,000) the force necessary to bring a moving car to rest instantly ..... A
Light weight of car ..... B
Load C

$$\text{Foot-pound factor} = \frac{B + C}{A} = D$$

Referring to the following table, opposite the foot-pound factor, corresponding to *D*, will be found the speed of car in miles per hour (*E*) and feet per second (*F*).

Foot Pound Factor (D)	Miles per Hour (E)	Feet per Second (F)
.033	1	1.4167
.134	2	2.9167
.300	3	4.3333
.535	4	5.7500
.930	5	7.7500
1.200	6	8.7500
1.640	7	10.2500
2.140	8	11.7500
2.640	9	13.1667
3.500	10	14.6667
4.070	11	16.0833
4.820	12	17.6667
5.660	13	19.0000
6.550	14	20.5000
7.480	15	21.9167
13.36	20	29.25
20.88	25	36.67
30.12	30	44.00
40.80	35	51.25
53.50	40	58.58
67.60	45	65.75
83.40	50	73.25
100.00	55	80.67
120.00	60	88.00

Disregarding friction of the lading on the floor or sides of car and considering the load moving at the rate *F* feet per second at the time the movement of the car is stopped, the load will strike the end of car with a force equal to that of a body falling a distance of *G* feet, which will be found in the following table, opposite the proper value of *F*.

"F" Velocity Feet per Sec.	"G" Height of Fall, Feet.	"F" Velocity Feet per Sec.	"G" Height of Fall, Feet.
.25	.0010	20.	6.22
.50	.0039	21.	6.85
.75	.0087	22.	7.52
1.00	.016	23.	8.21
1.25	.024	24.	8.94
1.50	.035	25.	9.71
1.75	.048	26.	10.50
2.00	.062	27.	11.30
2.50	.097	28.	12.20
3.00	.140	29.	13.10
3.50	.190	30.	14.00
4.00	.248	31.	14.90
4.50	.314	32.	15.90
5.00	.388	33.	16.90
6.00	.559	34.	17.90
7.00	.761	35.	19.00
8.00	.994	36.	20.10
9.00	1.260	37.	21.30
10.00	1.550	38.	22.40
11.00	1.880	39.	23.60
12.00	2.240	44.	30.00
13.00	2.620	51.	41.00
14.00	3.040	59.	54.00
15.00	3.490	66.	68.00
16.00	3.98	73.	83.00
17.00	4.49	81.	100.00
18.00	5.03	88.	125.00
19.00	5.61		

Therefore, the force of the blow exerted against the end of the car by the lading is:

$$C \times G = H \text{ pounds.}$$

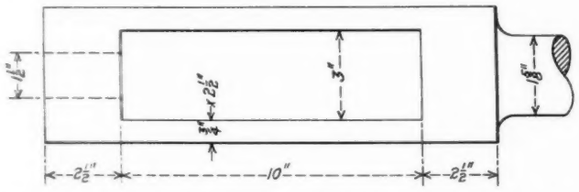
Consider the end frame a beam uniformly loaded for a length equivalent to the height of load in car, extending from one point of support. The bending moment of the end and corner posts and braces can then be figured in the usual manner for box cars, assuming the beam supported at end sill and end plate and for gondola cars consider the end stakes a beam supported at one end.

The foregoing is calculated on the assumption that the end frame will retard the lading and absorb the shock without distortion or penetration.

SHOP PRACTICE

FORGING MACHINE WORK AT SILVIS SHOPS

At the Silvis shops of the Chicago, Rock Island & Pacific, many parts are made in quantities and distributed through the store department over the entire system. The production of large amounts at one time has naturally led to the development of the cheapest and quickest methods of doing the work. One of the most interesting features of the practice



Driver Brake Slack Adjuster Made on a Forging Machine

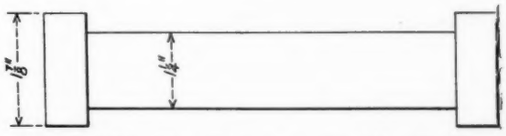
in the blacksmith shop is the extensive use of forging machines.

It has been found possible to do much work on the forging machines that was formerly shaped or welded under power hammers. Some parts which are usually made on automatic machines are also turned out at a considerably lower cost for both labor and material on the forging machines. An example of this is the spring roller pin shown below. These were formerly made from 1⅞-in. bar stock, the center portion being turned down in an automatic machine. They are now made on the forging machine, 1¼-in. stock being used, and the enlarged ends are formed by upsetting. The saving of labor and material by this method amounts to 20 cents for each piece. Brake rigging pins are made in the same way. Bushings for flexible staybolts also were formerly made on automatic machines. It was necessary to turn them from solid bars and the cost was $.025 each. Dies have now been made for forming these parts on the forging machine and the cost has been reduced to $.0044 each. It should be borne in mind that when such parts are forged it is often possible to use scrap material, thus effecting a further saving.

One of the largest savings which has been brought about on a single item was the result of a change in the method of making beading tools. It had been the practice to forge these oversize and mill them to the contour desired. The corners were then rounded by filing. It was found possible to produce a tool of almost exact shape required on the forging machine, the only finishing needed being filing off the fins. The saving by this method amounts to $.58 for each tool or $2,106 per year.

In making draw bar pins the head is upset and the hole for the key is then punched in the other end. This not only saves labor as compared with the method of drilling the hole for the key, but it reduces the amount of handling required as well.

The reduction in the cost as compared with forging by hand has shown the economy of making dies for all parts

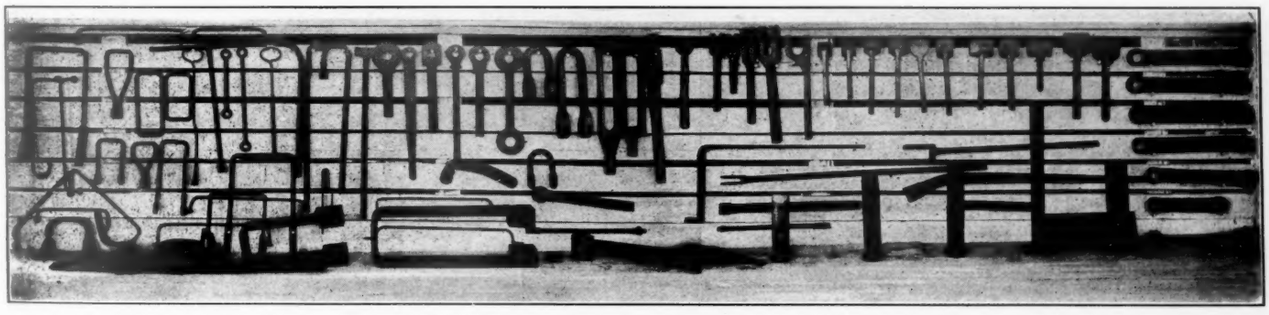


Spring Roller Pins Made on a Forging Machine

which are used in considerable quantities. On engine truck swing links, which are finished at one heat in the forging machine, the saving in labor is $1.16 each. Cranks for velocipedes, the labor cost of which formerly was $1.28, are now made at a cost of $.05 each. Clevises for safety chains now cost $.085 each as compared with $.44 when made by hand. In making safety chain hooks, the eye is first formed under a Bradley hammer. The piece is then bent in a bulldozer and finished in the forging machine. Eyebolts for safety chains are formed on the forging machine alone.

Among other parts for which dies have been made are ashpan wrenches, grate shaker bars, yokes for Waugh and Sessions draft gear, brake hanger posts, spring bands, eccentric blade jaws, knuckle pins, and screws for reversing gear. The last named parts when forged under a steam hammer cost $2.04 each, but they are now made at a cost of $.18 each.

Brake shoe keys when made under a power hammer cost



Example of Some of the Forging Work Done at the Silvis Shops of the Rock Island.

$.02 each for labor, while the present cost of making them on the forging machine is $.00375 each. Brake beam hangers with welded eyes are made on the forging machine which not only produces a stronger hanger, but reduces the cost as well. Strap spring hangers which when made by hand cost $.96 each are now turned out in one heat on the forging machine at a labor cost of $.16. The parts produced on the machine are far superior to any made by hand. The saving in this item amounts to $1,960 per year.

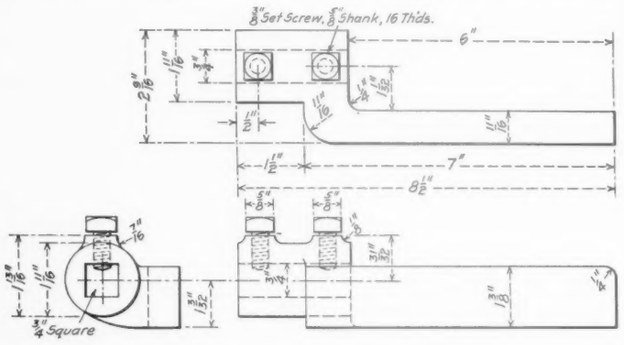
A rather difficult piece of work is the end for the driver brake slack adjuster, shown in the sketch. These are made in two heats on the 4-in. machine. The block for the end which carries the screws is placed in the machine between the two ¾-in. by 2½-in. side pieces and welded. The other end is made in much the same manner, the 1⅝-in. rod and a small block being placed between the ends of the side pieces. This piece is now made at a cost of $.37 each as compared with a former cost of $2.76.

At the present time the forging machine equipment at Silvis consists of one 4-in., one 3-in., one 2-in., two 1½-in. and two 1-in. machines. A 6-in. machine is now being installed on which it is planned to make drawbars, side rods, motion parts such as radius bars and eccentric bars. Dies will also be made for reclaiming axles.

LATHE BORING TOOLS

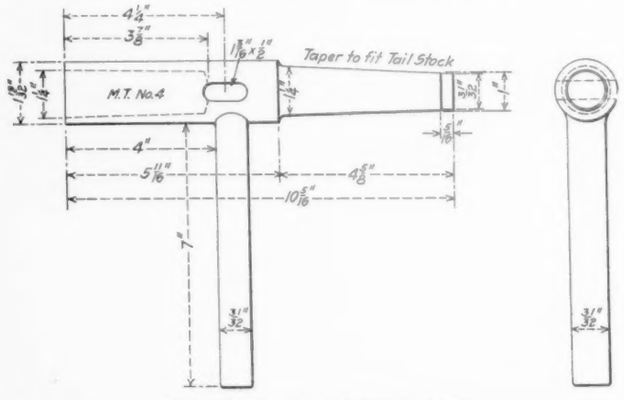
BY M. HERBLIN

The drawings and photographs show a lathe boring tool holder and a drill socket that have been in use at the Nashville, Chattanooga and St. Louis shops at Nashville, Tenn., for some time, where they have proved very efficient.



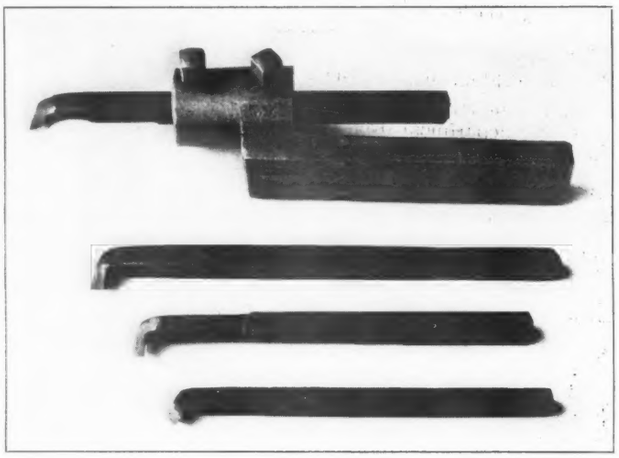
Details of the Lathe Boring Tool Holder

The lathe boring tool holder is made with the desired offset, having a shank 1⅜ in. by 11-16 in. High speed tools, ¾ in. square, are held in the holder by two ⅜-in. set screws. The entire length of the holder is 8½ in. The proportion of the holder may be changed so that much larger or smaller tools can be used. The tools are easily removed for grinding and they may be adjusted to suit the various depth of holes with but little trouble. This tool holder has a number of commendable features. It is very rigid and uses high speed steel tools that can be made economically, but little material being wasted.



Drill Socket for a Machine Lathe

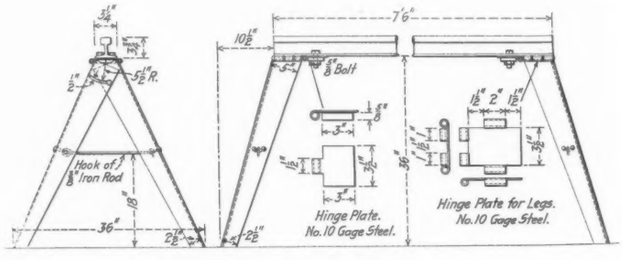
The drill socket is used for drilling holes on a lathe. The stem is turned to fit into the tail stock center. This holds the drill in perfect alinement and eliminates the trouble caused by the socket slipping from the tail stock center when the drill pushes through the work, as is the case with other sockets. The tail or arm of the drill socket is long enough to rest on the tool carriage and it relieves the tail stock of all torsional strain. This tool has been found very satisfactory and useful. It is made from 1⅝ in. material, the arm being 31-32 in. in diameter. It has a No. 4 Morse taper and is 10 5-16 in. long.



Lathe Boring Tool Holder For High Speed Steel Tools

FOLDING HORSE FOR SHEET METAL WORK

A device used in the Dale Street shops of the Great Northern which has been found very useful for jacket work in the erecting shop is a folding leg horse, a drawing of which is shown below. The legs are of No. 10 gage sheet steel bent to form an angle, and hinged so that they can swing inward.



Tinners Horse with Folding Legs

The plates to which the legs are fastened swing downward so that each pair of legs will fold over against the rail which forms the top of the horse. Since there is a considerable load on the inner hinge plates they should be held by a piece of ⅝-in. iron fastened to the base of the rail with two ⅝-in. bolts. A rail weighing about 40 lb. to the yard is the most convenient size for such a horse.

BOILER SHOP APPRENTICESHIP METHODS

The Santa Fe System Is Steadily Progressing With Its Educational Work in This Important Department

THAT the problem of boiler maker apprentice is regarded as of special importance on the Atchison, Topeka & Santa Fe is indicated by the large amount of attention that was given to it at the ninth annual conference of the apprentice instructors on that system. So important was the discussion of this subject considered that the convention was extended an additional day over the time allotted in order to complete it. The more important points of the discussion are covered in the article which follows. A similar report of the proceedings of the eighth annual Santa Fe apprentice instructors' conference will be found on page 415 of the August, 1916, issue of the *Railway Mechanical Engineer.*

ROUNDHOUSE BOILER WORK

This subject brought forth considerable discussion and no little criticism over past methods. It was found that entirely too much time had been given to finding a boy's weak points when transferred to another shop, so that his lack of knowledge could be criticized. It was agreed that this course should be discontinued and every effort be made by instructors to see that each boy is given the proper class of work. The instructor should feel just as much responsibility for the thorough training of a boy from another shop as for one of his own boys. When a boy is transferred from the back shop to the roundhouse, the shop instructor should furnish the other instructor and foreman a statement showing each class of work the boy had performed. Upon the boy's arrival, the instructor should talk with him and learn just what class of work he most needs, and what he is most deficient in. He should then consult with the foreman, and see that this work is given him. The assistant boiler inspectors who were present emphasized the importance of the apprentices being given experience in roundhouse work, and promised to do everything in their power to see that they were given a more thorough training than had been given these apprentices in the past.

FEDERAL AND COMPANY RULES—HOW TAUGHT?

It was suggested that these rules should be taught while the boys are engaged in the work to which they apply. Each apprentice will be supplied with one of the company's rule books, and should be made to study it during his apprenticeship. It was suggested that one school period each month should be devoted to the discussion of the boiler rules with the general boiler inspector, or one of his assistants, acting as chairman; the boiler foreman should be present, whenever possible. Not only should the rules be learned, but the boys should be taught their meaning and application. Failure to comply with these rules generally means defective work, and defective work endangers life and property.

WORK DURING FIRST SIX MONTHS

One instructor advocated a change of work each month during the first six months in order to study the nature and ability of the boy, and acquaint him with the work of the shop and his trade. He recommended increasing the kinds of work gradually from light to heavy, letting the boy learn during this period something of the different classes of work in the boilermaker's trade. This would also give the instructor an opportunity to study the boy, and would keep the boy interested and help to hold him on his apprenticeship, whereas, if he is kept too long on one class of work, especially at the start, he is likely to become discouraged and give up his apprenticeship. It was suggested that the apprentice be given some work in heating rivets during this first period, but that he should not be kept longer than two weeks on this class of work. During the first six-months' period he should have some sheet iron work, some work on ash pans, and some work in the tank room.

It was also suggested that shop instructors be placed at several of the smaller points, as they are greatly needed at such places. It is a paying proposition to give the boys a chance, to give them thorough experience in all classes of work.

One instructor recommended placing a boiler shop instructor at every point where there were at least five boilermaker apprentices; with such an instructor the number could probably be increased to ten or twelve. A foreman should not be allowed to keep a boy on any class of work simply because he has become proficient in that particular work and is of some personal help to the foreman in remaining there. The instructor should work in harmony with the foreman, but should see that the apprentice gets the experience needed to develop him into an all-round mechanic.

SUGGESTIONS FOR IMPROVING THE COURSE

G. Austin, general boiler inspector, brought out the inadvisability of attempting to train all apprentices for the more generally specialized classes of work, saying that all are not adapted to such training. He also recommended that efforts be more thoroughly devoted towards the development of mechanics rather than of foremen; that only a few could be selected for foremanship, while the mechanics were greatly needed. He stated, too, that there were a lot of good boys who could be developed for "coarser" work, whose ability would prevent their absorbing the special training which would be of advantage for certain of the brighter boys.

A greater number of boiler shop apprentice instructors was recommended; wherever five or more boilermaker apprentices are employed, a shop instructor should be appointed; it would then probably be possible to increase the number of apprentices.

The practice of advancing boys by specified time periods was discouraged, it being thought better to advance them according to their progress and ability. It was suggested that special meetings be held, say once a month, in the apprentice school room, the general boiler inspector, or one of his assistants, giving a lecture or other form of instruction to the apprentices and having the foremen and instructors present.

A more thorough training in the use of hand tools was recommended because of the limitations of pneumatic tools.

When defective parts of boilers are removed the attention of the apprentices should be called to the cause of removal, and the possible cause or the reasons which brought about this condition. It was also suggested that it would be well for the boiler inspector occasionally to take the older boys with him on a general inspection, when at terminals, to see what is being inspected, and why. It was suggested that in teaching laying-out work in the school room it would be well at times in addition to using drawing papers to lay the object out and cut and flange it from light weight iron.

It was also recommended that every apprentice be sup-

plied with a book of boiler rules, and be taught the information and instructions therein.

SCHOOL ROOM COURSE FOR BOILERMAKERS

This subject has been discussed by the instructors for some time and the need for a distinctive course for boilermaker apprentices is apparent. The course as recommended will differ but slightly from the regular school work for machinist apprentices for the first nine months. The first 50 lessons in drawing will be the same, after which such drawings as relate to boiler work, radial development, intersections, triangulation, etc., will be begun. The work in the school room should at all times be as closely related as possible to the shop work being done by the boy. A definite number of drawings and problems must be completed by each apprentice during each six-months' period.

In laying-out work taught in the school room the boy should work from prints similar to those used in the shop. Each step should be thoroughly understood before taking up advanced work.

In mathematics, the course will include in addition to the present problems specially prepared problems on boiler work, strength of materials, riveted joints, including the use of formulas. It is imperative in these days for a boilermaker to be able to use formulas for calculating seams, joints, staying, etc. Boilermaker apprentices should be taught enough of the principles of algebra so they may be able to obtain an adequate working knowledge of these formulas.

Questions on boilermaking will be used as a guide and should bring to the boy's mind the important features of his trade, which he should know and remember. The questions will be given at regular intervals throughout his apprenticeship, but in the last six-months' period he will be required to write out answers to all questions. This will be a review, and will enable the instructor to ascertain if there are any features with which the boy is not thoroughly familiar; and if so, he will be able to go over the subject with the apprentice before he graduates.

LAYING OUT—HOW TAUGHT IN THE SHOPS

It seems to be the general practice of the boiler shop instructors to give the apprentices sheet iron work and light laying out in their first year, and heavy laying out, such as belly patches, side sheets, back sheets, door sheets, throat sheets, flue sheets, etc., in the fourth year of their apprenticeship. The apprentice should work with the regular layer out, or where there is more than enough work for one man, the instructors should be in charge and give the apprentice the necessary instructions. The boys at many places are given laying-out work in the school room. This should conform with the work he is doing in the shop at that particular time. The object should be laid out on as large a sheet of paper as convenient, and should later be cut and rolled to shape.

STATIONARY BOILER RULES

Owing to the introduction and passage of so many state laws regulating the care and maintenance of stationary boilers, it was suggested that additional questions be added to the list of questions for boilermaker apprentices covering the principal features of the new state laws. While the majority of these requirements are covered by the Santa Fe book of boiler rules, still there are some features that are not covered, and it was suggested that whenever a state passes any law or adopts any rule as to the care and maintenance of stationary boilers, the apprentice schools in that state should provide copies of these regulations for the information of the instructors and the thorough instruction of the apprentices.

QUESTIONS ON BOILERMAKING

Questions recently prepared on boilermaking for the instruction of the boilermaker apprentices had been previously assigned to the boiler shop instructors, who had been asked to write out the correct answers to these questions. These answers were thoroughly discussed with the shop instructors and with the general boiler inspector and his assistants, and after a thorough discussion, they were submitted to the general boiler inspector for verification, with the understanding that each boiler shop instructor would later receive a copy of the correct answer to each of the questions, in order to compare it with the one he had previously submitted, and that he might be sure of the correct answers and interpretations.

BRICK ARCHES

G. M. Bean, western representative of the American Arch Company, suggested that while formerly the brick arches were applied as fuel savers, they were now considered more as boiler capacity increasers. A great benefit is secured from arch tubes as a circulating agent and in increased evaporation. Mr. Bean spoke of the necessity of taking good care of the bricks in storage, keeping them under shelter and free from moisture; avoid rough handling as all fire brick is more or less fragile, and cannot be handled like stone or vitrified brick. The design and location of the arch tubes is the result of considerable experiment, and the shape and position of these tubes indicated on the blue prints should always be adhered to. Keep the flues clean, especially the lower ones. While at times it may be inconvenient to get to them, it is necessary that they should be kept clean if economical results are to be accomplished. When the arches are properly applied and maintained, longer life will result for both flues and fireboxes, as the arches will distribute the heat more uniformly over the entire firebox; on account of the even distribution of the heat the cinders and gases will be consumed rather than pass through the flues and out of the stack, thereby making it a smoke consumer.

LOCOMOTIVE SUPERHEATERS

R. R. Porterfield, of the Locomotive Superheater Company, gave an illustrated talk to the instructors on the installation and maintenance of the superheater.

APPLICANTS—HOW SECURED

Arthur Irving, Chanute, Kan., was assigned to this subject owing to his success in securing applicants at Chanute. He attributed his success in securing these applicants to his being in thorough touch with each of his apprentices; most of the applicants had been secured from among friends of his apprentice boys, or from friends of their friends. There are various ways of securing applicants—by solicitation through the apprentices, fraternities, Sabbath schools, or occasionally talking with a small gathering on the street, when he happened to be down town. He also had found it a good plan to occasionally go to the neighboring towns, and talk with the young men there. It was suggested that the instructor should keep in close touch with the public schools, occasionally giving a talk to the high school students, or at least explaining the situation to the high school teachers in order that they may present the matter to such of their pupils as are interested.

All the instructors agreed that loafers, or boys from poolrooms, made very poor apprentices. In talking to a prospective applicant, it was pointed out that the young man should be made to realize that in this day and age it is very necessary to have either a good education or a trade, or better still, both; that unless he has one or the other he will be doomed to work for mere laborers' wages, and be compelled to compete with the lowest class of laborers. If

this matter is thoroughly brought to the attention of these young men, many of them will be induced to go into a shop to learn a trade.

Mr. Irving pointed out that the instructor could well afford to make a personal sacrifice occasionally to help out some deserving boy, who perhaps is unable to pay the surgeon's fee, or possibly unable to pull through during the first period of his apprenticeship.

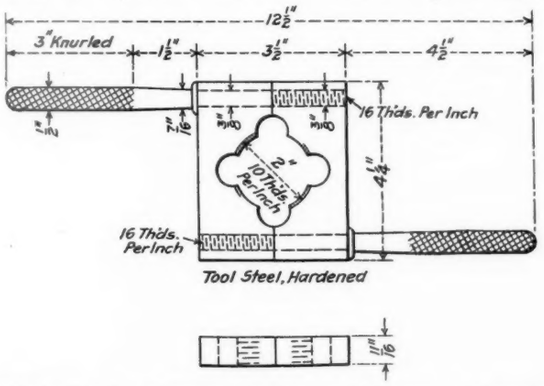
When a prospective applicant complains about the apparently low rate of pay, he explains the reason for this, and also calls attention to his having a chance to work every day and to what the average wage throughout apprenticeship really amounts to. Each boy is urged to look toward the future and make his plans accordingly.

In giving the school examination to applicants for boilermaker apprentices, all agreed that the instructor must make considerable allowance and if the boy seems physically strong, of clean morals, and is ambitious, that he should not be rejected on account of his deficiency in schooling. The importance of the moral element in passing upon the fitness of a boy for a trade was emphasized. In connection with this, the subject of cigarette smoking was thoroughly discussed. If a boy is addicted to this habit, he should be taken in hand and be given a fatherly talking to. If the boy does not quit smoking cigarettes, he should be made to understand that he must either quit the habit or give up his trade; usually the boy chooses to give up the cigarettes.

The instructors reported that a higher rate should be paid in order to attract boilermaker apprentices. At some points there seem to be plenty of applicants, but when the question is raised of sending some of these boys to other points, it has been found that although they could live at home on the wages paid, they cannot go to another shop where they have neither credit nor relatives, and be able to pull through. It was suggested that in certain cases relief might be obtained by employing prospective applicants first as rivet heaters. This would give the boy a chance to become familiar with the shop and in certain cases enable him to get a little bit ahead financially, before starting on his apprenticeship. The question is under consideration of letting the boilermaker apprentices, or at least the most deserving ones, serve a part of their apprenticeship, say six months, in the machine shop, in order that they may be better prepared for promotion when vacancies occur.

DIE FOR REPAIRING THREADS ON CROSSHEAD PINS

The details of an adjustable die which is very useful for cleaning up injured threads on crosshead pins, knuckle joint pins and crank pins are shown in the drawing.



Adjustable Die for Cleaning Up Battered Threads on Crosshead, Crank and Knuckle Pins

When men are working around an engine, or when the pins are being handled, it often happens that the threads are damaged. They have to be only slightly battered to prevent the starting of a nut on the end of the pin. To secure a large socket die to clean up threads in this condition is inconvenient and rather expensive because of the time usually required. Where the threads of this description are standardized on the various classes of engines, the simple adjustable die, which may always be kept at hand for the purpose, is equally as effective and much more convenient.

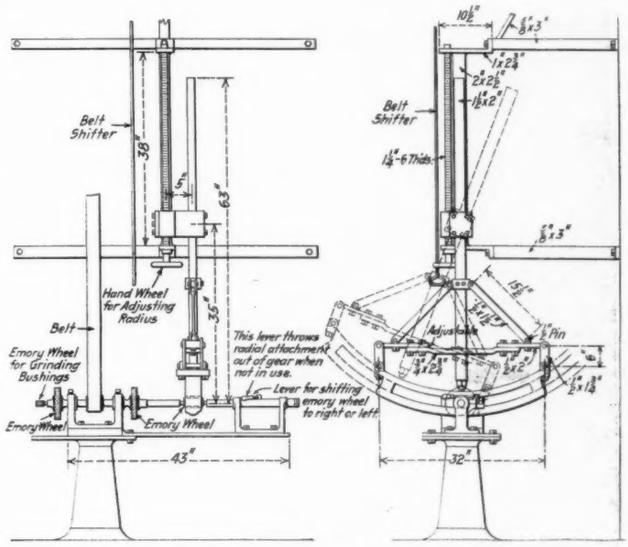
The die is made in halves which are joined by handles placed at diagonally opposite corners. Each handle passes through one die and is threaded into the other. To use the die it is opened and slipped over the end of the pin, after which it is closed on the thread by screwing up the handles. The threads are cleaned up by running the die off the pin.

RADIAL LINK GRINDER

BY J. H. CHANCY
Foreman Blacksmith, Georgia Railroad, Augusta, Ga.

In many shops no provision is made for resurfacing valve motion links except to anneal them and true them up on the bench by draw filing. This requires anywhere from two to three days' work. In order to make it possible to do this work by grinding without the necessity of annealing the links, a simple radial attachment was developed by F. B. Kuhlke, in charge of rod and link work at the Augusta shops of the Georgia Railroad, which is used with an ordinary two-wheel pedestal grinder.

The foundation of the radial attachment is a column 2 in. by 2½ in. in section and 40 in. long, with flanges at the top and bottom to which are bolted brackets of ⅝-in. by 3-in. material. These brackets support the column from the wall of the shop. The flanges at the end of the column also serve as bearings for a long 1¼-in. screw with a handwheel at the lower end. Mounted on the column is a sliding head, the position of which is adjusted by the screw. To one side of this head is pivoted a block in which the adjustable radius arm is clamped.



A Shop-Made Radial Link Grinder

The method of attaching a Southern valve gear link to the radius arm is illustrated in the drawing. The yoke to which the ends of the link are attached with eye bolts and 6-in. links of ½-in. by 1¾-in. material, is triangular in form, the base being connected to a sliding block on the radius rod by two ½-in. by 1½-in. links, 15½ in. long. With the sliding block properly adjusted and securely clamped to the

radius rod, the valve motion link is rigidly supported by a jack screw in the end of the radius rod which may be set up tight against the inner curve of the link. In adjusting either Stephenson or Walschaert links, turnbuckles are used in order that the link may be accurately squared up with the radius rod.

To one side of the grinding wheel stand is attached a bracket, the outer end of which contains an outboard bearing for the link grinder shaft and a shifting lever arranged to throw the link grinder attachment out of gear when its use is not required.

By means of the adjusting screw on the column of the radius attachment, the pivot of the radius arm may be raised or lowered on the column to provide for a range of link radii from 35 in. to 63 in. After the radius arm has been adjusted to the proper length in the pivot block, the final adjustment of the height of the pivot is made with the hand-wheel so that the grinding wheel may be passed through the link, and the work fed against it.

The machine was built at a nominal cost of about $50, most of the material used being selected from available scrap. It was built in the shop at such time as the labor could be spared from the regular work. With this machine, work that originally required from two to three days' draw filing by hand, may now be done with better results in two hours.

GAP RIVETER FOR STEEL CAR REPAIRS

BY "APEX"

The gap riveter shown in the illustration is used for riveting sheets in open steel cars on a South African railway. It is made up of a 5-in. pipe bent as shown and in the ends of

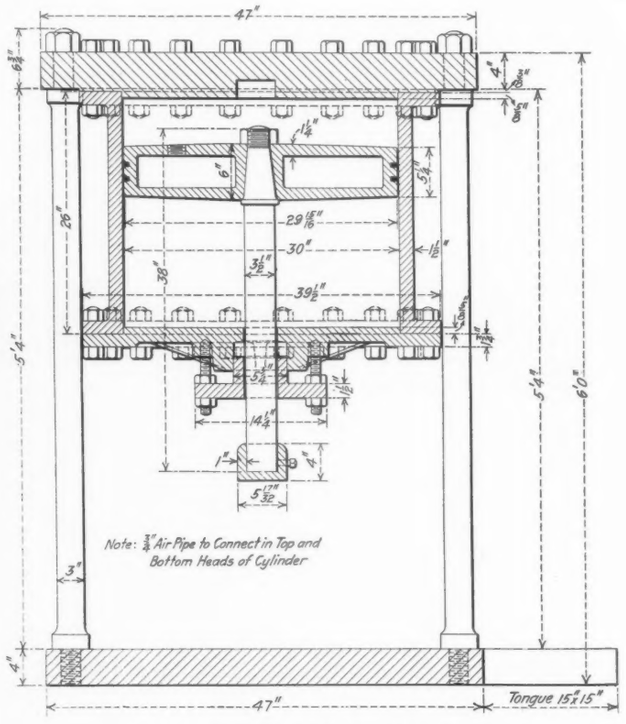
Gap Riveter for Repairing Steel Cars

which are placed the anvil and air operated plunger. It is hung on a cradle made from 1½-in. by 1-in. bar iron with bossed ends for the trunnion pins. These pins are contained in clamps made of 3½-in. by 5-in. material. These clamps are bolted securely to the pipe and are so placed that the machine is nicely balanced. The riveter is supported by a chain hoist on a crane by a shackle at the top of the cradle so that it may be adjusted to any desired position. While it is not claimed that this riveter will perform the work faster than when a hand riveting machine is used, it is much easier for the workmen and a better rivet is made. It has been found to be especially advantageous where heavy repairs are made or new work is being done.

AIR PRESS FOR ROD BUSHINGS AND DRIVING BRASSES

BY E. A. M.

A convenient air press which can be made in most any shop and which has been found particularly serviceable in rod and driving box work, is shown in the illustration. The cylinder of the press has a diameter of 30 in. The press is made up of a base 4 in. thick by 47 in. square with a tongue



Air Press of 70,000 Lb. Capacity

on one side 15 in. square. This projection is left on the base as it enables the operator to get the work on and off the press easier. Four wrought iron upright columns of 3-in. diameter are screwed into the base and the top plate of the press is held to these rods by four 2½-in. nuts.

The air cylinder walls are bolted to the top plate by 20 1⅛-in. bolts. The underside of the top plate is cut away as indicated in the illustration to permit the top plate fitting into the cylinder, the upper plate forming the head of the cylinder. A cast iron piston with two packing rings is used on a 3½-in. piston rod. The bottom head of the cylinder is fastened to the wall by 20 1⅛-in. bolts. It is strongly reinforced by six ribs. A suitable packing gland is applied on this end of the cylinder. It is made of brass and held in place by two 1-in. studs. The cylinder may be operated by the regular three-way valve and at 100 lb. air pressure it will provide a pressure of about 70,000 lb.

FEDERAL INSPECTION REQUIREMENTS*

A Suggested Outline of the Methods Followed in Making Inspections and Keeping Records of Them

WE all realize that in the tremendous strains of present day railway service, equipment in general must necessarily wear out and of course receive necessary repairs at the proper time. In order to determine definitely the condition of the motive power at all times, our attention must be given to the subject of inspection, especially so, where the power is used in pool service. The theory of which is to eliminate defects before the power is returned to service, or if necessary, remove the power from service as soon as defects have appeared. It has become almost universal practice to place the very best mechanic obtainable on this class of work, giving him authority to remove the power from service if necessary to have proper repairs made.

In order to facilitate the handling of the work, as well as other inspections, etc., required by the federal laws, it is imperative that some effective system of procedure be installed.

Realizing the impracticability of attempting to formulate a basic rule whereby the various requirements of the federal laws could be complied with under conditions found at different shops and terminals, it has been decided to arrange the various items under headings, with suggestions as to the method of handling.

Every foreman must necessarily organize a system of procedure to best suit his particular shop conditions.

BOILER INSPECTION

Interior Inspection.—It is general practice to have the interior of the boilers inspected by the boiler shop foreman or his assistant when locomotives are in the back shop receiving repairs. When sufficient number of flues are removed to allow examination, while the locomotive is undergoing light repairs in roundhouse, the foreman in charge of roundhouse boiler work usually makes the inspection. A combination of water and sand blast has been used with some success to remove boiler scale. However, the standard practice is using a special scaling tool with a small pneumatic hammer.

Flues.—Records of flues kept in all boiler shop offices will enable the foreman in charge of boilers to see that the three-year limit is not exceeded.

Exterior Inspection.—In order to relieve the roundhouse of as much work as possible, the entire removal of the jacket and lagging should be made when the locomotive is receiving classified repairs in the back shop, if it is found that complete removal of lagging will be necessary before the locomotive receives the next general repair. This, of course, sometimes results in lagging being removed several months before it is due. However, the stopping of serviceable power, when it is no doubt badly needed, is avoided.

Testing Boilers.—A common method of making the hydrostatic test is by the use of a pump operated by compressed air, arranging a drain pipe to one or two gage cocks so a steady pressure may be maintained in the boiler and at the required amount while the boiler is being examined. The testing of the boiler is witnessed by the boiler shop foreman, his assistant or the regularly assigned inspector.

Stay-bolt Testing.—It is practical to have one or more men regularly assigned to stay-bolt inspecting, as they will soon become highly proficient at this work. They also inspect tell-tale holes, see that they are kept open at all times. The inspection and removal of broken stay-bolts, each time the boiler is washed, is found to prevent delays to the locomotive when the regular monthly inspection is made. The work of removing and applying stay-bolts should also be assigned to a regular man.

Steam Gages.—If possible, all steam gages should be tested and repaired at a central point and the work specialized. This not only prevents a large amount of repair parts being kept in stock, but insures good workmanship. While isolated terminals are not expected to make extensive repairs to gages, they should, however, be provided with a dead weight tester, in order to satisfy themselves as to the correctness of gages when in doubt.

Safety Valves.—The safety valves should also be repaired by a specialist and handled in the same manner as steam gages wherever practicable. In most cases it is possible to consolidate the work.

Water Glass and Gage Cocks.—It is the practice on a great many roads to clean the scale and sediment from water glass gage cocks at the same time the locomotive is given the monthly inspection. Some roads have a man regularly assigned to this work, and make it a practice to not only clean the water glass and gage cock, but also clean and grind boiler checks and repack all cab cocks every time the boiler is washed out.

Injectors.—It has been found good practice to specialize the repairing of injectors, the work being taken care of in the air brake department and coming directly under the foreman. They should be tested at the engine house upon arrival of the locomotive, as well as before departure.

Washing Boilers.—The round house foreman is held responsible for boiler washings and must see that all plugs are removed and that the boiler is thoroughly cleaned and that the washout card is punched. He must also know that all arch and water tubes are thoroughly cleaned. A convenient card which is made in triplicate for recording boiler washings is shown below:

THE RAILWAY CO.

Spindle of Gage and Water Glass Cocks removed and cleaned by .....

RECORD OF BOILER WASHING

Place .....

Eng. ..... *Initial* .....

..... *B. W.*

Punch month and date Boiler is washed

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	1	2	3	4	5	6		7	8		
	9	10	11	12	13	14		15	16		
	17	18	19	20	21	22		23	24		
	25	26	27	28	29	30		31			

Filing Reports.—The matter of filing as well as the handling of inspection reports must necessarily be taken care of in a way to best suit local conditions. In order to facilitate the work for the clerk in making out the forms covering various inspections, a form similar to that shown in Fig. 1 has been found of great assistance. This form is made out and signed by the inspectors.

Fig. 2 shows a convenient cab frame to accommodate Forms 1 and 3. The forms as well as the glass can be easily applied or removed, and the forms will be kept in a clean condition.

LOCOMOTIVE AND TENDER INSPECTION

In the general design and construction of the locomotive depends in no small way the cost of maintenance, and in

*Abstract of a committee report published in the advance papers of the General Foremen's Association.

a great many cases, details of an apparently minor nature are overlooked, which cause an endless amount of difficulty in maintaining the power in a satisfactory condition. It is the duty of every foreman to advise his superior officer of any change he thinks would decrease the cost of maintenance in any way. This is particularly true when the company is contemplating the construction of new power.

Inspection and Work Reports.—A system of handling inspection and work reports must be worked out to best suit shop conditions. The locomotive inspector's report and the engineer's report should not be allowed to leave the round-house office, the work being distributed to the repairman on a separate report, similar to that shown in Fig. 3, being signed and returned by the repairman after the work is completed. The repairman's reports are filed in round-house office for reference, and quite often are instrumental in placing responsibility for engine failures.

THE RAILWAY CO.

Engine No.....

Engine House .....

Date .....

1. Number of flues removed?.....
2. Were all flues removed?.....
3. Was dome cap and throttle stand pipe removed?.....
4. Was lagging on fire box removed?.....
5. Was lagging on barrel removed?.....
6. Safety valves were set this day to pop at .....lbs. .....lbs.....lbs.
7. If hydrostatic test was made, give pressure applied .....lbs.
8. Were caps removed from all flexible staybolts?.....
9. Condition of exterior of barrel.....
10. Condition of interior of barrel.....
11. Condition of flues .....
12. Condition of arch tubes.....
13. Condition of water bar tubes.....
14. Condition of firebox sheets.....
15. Condition of staybolts .....
16. Condition of radial stays.....
17. Condition of sling stays.....
18. Condition of cross stays.....
19. Condition of throat stays.....
20. Condition of crown stays.....
21. Condition of crown bar bolts.....
22. Condition of crown bar braces.....
23. Condition of dome braces.....
24. Condition of back head braces.....
25. Condition of front flue sheet braces.....
26. Were steam gages tested and left in good condition?....
27. Were both injectors tested and left in good condition?....
28. Was boiler washed?.....
29. Were gage cock and water glass cock spindles removed and were cocks cleaned?.....
30. Were all steam leaks repaired?.....
31. Were fusible plugs removed and cleaned?.....
32. Number of broken crown stays and staybolts removed?....
33. Were draw bars and draw bar pins inspected?.....
34. Were air gages tested?.....
35. Were air pumps tested?.....
36. Were distributing or control valves cleaned?.....
37. Were reducing valves cleaned?.....
38. Were triple valves cleaned?.....
39. Were straight air double-check valves cleaned?.....
40. Were dirt collectors cleaned?.....
41. Were brake cylinders cleaned and lubricated?.....
42. Were main reservoirs hydro tested?.....
43. Were main reservoirs hammer tested?.....
44. Condition of brake and signal equipment.....
45. Condition of draft gear and draw gear.....
46. Condition of driving gear.....
47. Condition of running gear.....
48. Condition of tender .....

.....

Inspector.

Fig. 1—Form for Recording Boiler Inspections

Ash Pans.—At most locomotive terminals it has been found advisable to have a special inspector for ash pans, grates, shaker rigging and smoke box netting, etc. It is his duty to also make inspection after repairs have been completed, and make necessary notation in record book. A record of this kind is very valuable in case of law suits due to fires along right of way.

Time of Cleaning and Inspecting.—It is essential that an accurate record be kept of all tests, and that the foreman and repairman will have some means of knowing when a locomotive is due for one or more of the various tests. In some instances a test bulletin case is installed at some convenient point in the round-house, where it is accessible to all repairmen. The bulletins should give the engine number and date various tests are due, and should be checked off when completed.

Draw Gear and Draft Gear.—In addition to regular quarterly inspections of draw-bars and pins, safety bars and safety chains, it is good practice to make careful examination for defects at any time the tender might be disconnected from the engine, and lost motion between the engine and tender taken up. The application of radical chafing castings provided with slack adjusting wedge, has been found of great assistance in preventing lost motion between engine and tender.

Cross Heads.—The methods of maintaining crossheads in a suitable condition depends entirely upon the style of cross-head. Where side plates are used, it has been found practicable to apply two 1/16-in. liners between the crosshead and side plate, which enables repairman to take up ¼-in. lateral.

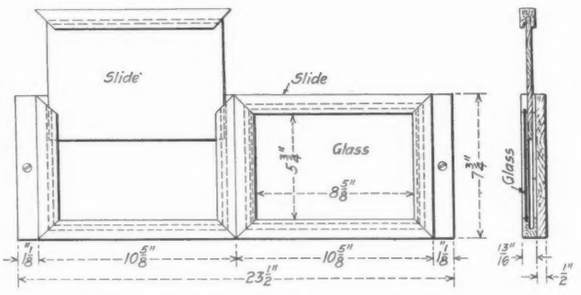


Fig. 2—Cab Frame for Inspection Records

Guides.—The common practice is to plane the guide bars when they become worn. However, some shops have found it practical to electric weld the guide before planing, maintaining the original width. They should be relined to the standard spread and sufficient liners applied to insure obtaining maximum wear on crosshead gibs and enable the repairman to maintain the piston rod central in the stuffing box.

Piston and Piston Rods.—Pistons are renewed if worn 3/16 in. smaller than the cylinder when locomotives are receiving general repairs. A limit of 5/16 in. is the general practice in the round house. Piston rods are given close inspection for defects each time they are removed, the hammer test being found very effective. It is also good practice to anneal the crosshead and piston fits whenever possible. Rods are renewed when reduced to ¼ in. below the original size, 1/16 in. being allowed for wear at last turning.

The Railway Co.

LOCOMOTIVE WORK CARD No._____

Eng. No. | Eng'r____or Insp.____ | Place and Date

Work Performed by | Date

Fig. 3—Repairman's Report

Main and Side Rods.—All main and side rods are given special inspection in the erecting shop, the hammer test being used. Side rod bushings are not permitted to go out

of the shop, if more than 3/64 in. larger than pin, and are made larger than pin, and are made 1/16 in. longer than pin to accommodate liners between the collar and pin, for the purpose of taking up lateral. If excessive lateral still exists after liners have been removed, and the rod bushing is still serviceable, a loose brass liner of proper dimensions can be applied. All side rods should be carefully trammed before being placed in position.

Axles.—Driving, trailing, engine truck or tender truck axles are not placed in service if they are out of round, or have a taper of more than 1/32 in. in the length of the journal.

Crank Pins.—It is considered good practice to remove the crank pin when it is worn 3-16 in. below its original size. The outside diameter of the crank pin collars should be at least ¼ in. larger than the side rod bushing to prevent the side rod interfering with other parts of the locomotive should the bushing become loose while the locomotive is in service.

Driving Boxes.—The use of cast steel driving boxes has almost totally eliminated breakage of this important part of the locomotive. Pouring the crown bearing and the hub plate solid has been found very successful and eliminates loose crown bearings. In order to eliminate the maintenance of solid brass shoes and wedges, the boxes are made ¾ in. below standard size, and brass liners ⅜ in. thick are applied to the shoe and wedge face of the box. Where

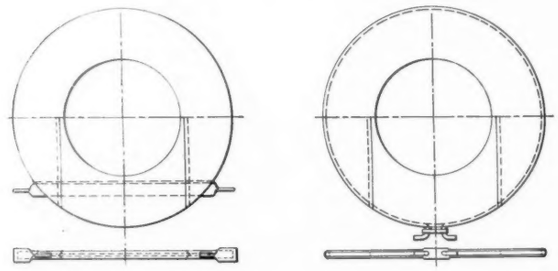


Fig. 4—Type of Lateral Plates that Have Been Used with Success

a brass foundry is available this work can be facilitated by planing dove-tail grooves in the shoe and wedge face of the box and pouring the brass on, the box is then planed to the standard size.

Lateral Motion.—The practice of applying brass plates between the driving boxes and the hubs of driving wheels where the lateral has become excessive is followed generally. However, this is usually considered as temporary repairs. Lateral plates are not difficult to manufacture or to apply, being dovetailed and held together with a key or round iron band fitted into groove around outside edge. (See Fig. 4.)

Spring Rigging.—The use of case-hardened pins and bushings in spring rigging has become a necessity, especially on heavy power. Since the enginemen cannot be depended upon to properly oil the spring rigging, and it is essential that it be lubricated, it is necessary that some one in the round house organization be regularly assigned to this work.

Driving and Trailing Wheel Tires.—All round houses should be provided with a chart, preferably framed and under glass, showing the axle load, diameter of wheel center, minimum thickness of tires for road and switching service, covering the various classes of power, which is not only a time saver, but minimizes the liability of foreman and inspectors making mistakes regarding limit of tire thickness permissible.

Record of Tests.—Book records of all tests must be kept, preferably in one office, which usually requires services of a special clerk. It is his duty to issue bulletins showing when engines are due for the various tests, write up certificates, see that they are properly signed, and he sometimes holds a notary commission.

It has been found very convenient to make the regular monthly and quarterly inspections at the same time, and the semi-annual inspection with every second quarterly inspection, the annual inspection with every second semi-annual inspection, which not only facilitates handling the work, but is of great assistance in keeping records.

The following are samples of bulletins regarding inspections posted in round houses for the information of the foremen and repairmen:

..... May 30, 1917.

To all engine inspectors and foreman:

The following is list of engines due for Hydrostatic, Quarterly and Flexible tests during the month of June, 1917, also engines due for removal of lagging from barrel:

	Quarterly	Hydrostatic
June 1		257 6-1
June 2	171 237	254 6-16
June 3		78 6-21
June 4	101 242	
June 5	73 173	
June 6	169	
June 7	106 177 232 254	
June 8	160	
June 9	236 249	
June 10	226	
June 11		
June 12	260	
June 13	123 229	
June 14	96 158 252	
June 15	84 264	Flexible Tests
June 16	116 127 152 269	260 6-17
June 17	270	225 6-22
June 18	109	226 6-24
June 19		227 6-30
June 20		
June 21	128	
June 22	268	Lagging
June 23		None
June 24		
June 25		
June 26	113 108 235	
June 27	265	
June 28		
June 29	181	
June 30		

..... May 30, 1917.

To all engine inspectors and foreman:

The following is list of engines due for inspection of draw bars, draw bar pins, air gages, air pumps, distributing of control valves, reducing valves, triple valves, straight or double check valves, dirt collectors cleaned and cylinders cleaned and lubricated during the month of June, 1917:

Draw Bars, etc. 3 month test.
73, 77, 78, 79, 84, 86, 90, 96, 101, 106, 107, 109, 113, 116, 123, 127, 128, 152, 158, 160, 164, 165, 168, 171, 173, 175, 177, 179

Distributing Valves, etc. 6 month test.
86, 106, 123, 152, 158, 177, 226, 229, 232, 235, 252, 254, 257

Hydro test Main reservoirs. 12 month test.
77, 78, 103, 155, 165, 257, 270, 275, 189, 101

Hammer test Main reservoirs. 18 month test.
None.

The report is signed by: J. B. Wright, chairman; C. D. Rafferty, H. W. Heslin, B. L. Davies and G. W. Ingrund.

SOME OXY-ACETYLENE REPAIRS

Some roads in the bad water districts experience considerable trouble with pitted flues to the extent that the flues do not give anywhere near their proper mileage. At one large

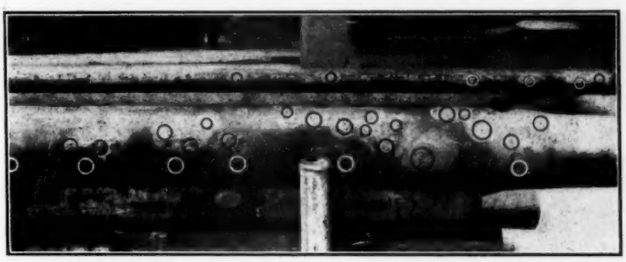


Fig. 1—Pitted Flues Welded by the Oxy-Acetylene Process

shop where these conditions exist it has been found possible to fill up these pits with metal by the oxy-acetylene process. The flues are hammered around the pits so that all scale and

dirt will be removed before the pits are welded. So many pitted tubes are received in this shop that a regular organized force is formed to handle this work. Fig. 1 illustrates the end of a large and small flue which have been repaired in this way. They were picked indiscriminately from a large pile and circles have been drawn around the welded pits in order to bring them out more clearly. These clearly show the extent to which the welding is done. These flues are, of course, in otherwise good condition and the pits have not been allowed to get too deep before the welds are made. Those flues that are too badly pitted are scrapped. This road handled over 6,000 such flues during a year at a cost slightly over one

Fig. 2—Example of Welds on Transoms

dollar per flue. The life of the flue is just about doubled. This represents a very substantial saving, particularly so at the present time on account of the increase in cost of these products.

At this same shop considerable work is done in reclaiming bolsters by the oxy-acetylene welding. Figs. 2 and 3 show examples of some of the work that has been done and that was laid aside to be done. The transom in Fig. 2 had previously been broken, as shown by the white chalk line. The old weld was previously repaired by the oxy-acetylene process and the proximity of the new to the old break indicates how well the first break was welded. A second break occurred,

Fig. 3—Cracked Transom to Be Repaired

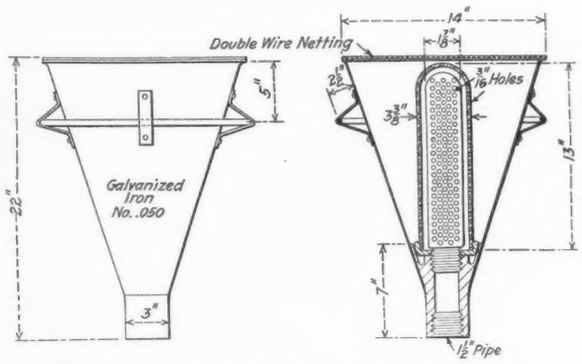
which was cut out as indicated, by the oxy-acetylene flame preparatory to rewelding. This practice is followed in all such welds. Fig. 3 shows a bolster that was received at the shop to be repaired. This clearly indicates the extent to which this welded work is carried on. On over 300 bolsters thus repaired, a net saving of over $4,000 was made over the cost of the new bolsters.

This work well indicates what may be accomplished by this process and with the price of materials so high at the present time every effort should be made to reclaim as much material as possible.

MUFFLER FOR USE IN BLOWING DOWN BOILERS

BY C. W. SCHANE

The drawing shows the details of a simple muffler which is in use at the Huntington, Ind., roundhouse of the Erie, for blowing down boilers preparatory to washing out or making repairs. The discharge of steam from the boiler directly to the atmosphere through the restricted opening of the ordinary small blow down pipe is extremely noisy and confusing. The muffler materially softens the sound of the escaping steam and makes working conditions in the vicinity much more agreeable.



A Simple Shop-Made Muffler for Blowing Down Boilers in the Roundhouse

The device may be made in any pipe shop at very little expense. Two tubes perforated with equally spaced 3/16-in. holes are inserted in the center, and the casing is made of No. 05 galvanized iron. The cover is made of double netting. An iron ring is riveted on the outside in order that the muffler may be handled conveniently when hot.

PROPER ALINEMENT OF LOCOMOTIVE PARTS*

This subject is a very broad one and practically takes in the locomotive in its entirety. A few suggestions are offered with the hope that they may be of benefit.

First—Level the boiler until the center line is in a horizontal position, then level the firebox till the vertical center line is vertical.

Second—Fit the cylinder saddles so the center line will be parallel to the center line of the boiler, regardless of the smoke box, with the back faces at right angles thereto.

Third—Line the frames at right angles to the back joint faces of the cylinders, and thus make them parallel to center lines of the cylinders.

Fourth—Locate the centers of the pedestal jaws on the frames for the shoes and wedges so that the driving boxes and axles will be 90 deg. with the cylinder line (too much care cannot be taken with this part of the alinement). There are quite a number of different methods used in squaring the shoes and wedges, with the object in view of bringing the wheels square with the frames and cylinders, a few of which are as follows:

A line is passed through the cylinders, being made central to the counter bore of each end of the cylinder, and run well back of the main pedestal jaws. A straight edge is then placed across the main jaws at perfect right angles to this line, using a true two-foot square along the straight edge, allowing it to "feel" the line which is drawn through

*Abstract of a paper published in the advance report of the General Foremen's Association.

the cylinders (see Fig. 1). If the straight edge is not perfectly square with the line it will then be necessary to place shims between one of the jaws and the straight edge until it is. After this has been done draw a vertical line on the side of the frame square with the top of the frame and letting the blade of square "feel" the edge of the straight edge. This will be what is termed as the "square line" and from this should be drawn a second line at right angles to the first on each frame and at the same distance down from the top of the frame. From this the centers on the main jaw are located and from these centers and with trams set to the rod lengths the centers on the other jaws are located. After these centers have been obtained lay off half the diameters of the boxes each side of the centers and after the shoes and wedges have been placed in position, with binders tight, draw vertical lines down on the shoe and wedge, half the diameter of the box plus one inch. This line is used for setting up shoes and wedges on the planer, and if the work is properly done this method will answer very well. It should be borne in mind that the cylinder casting should be located exactly central between the frames.

There are various other methods used for lining shoes and wedges, but the object is the same and it is only a difference of opinion as to which is the best. However, whichever method is used it cannot be done too carefully, for without care driving box trouble, rod brass trouble, and

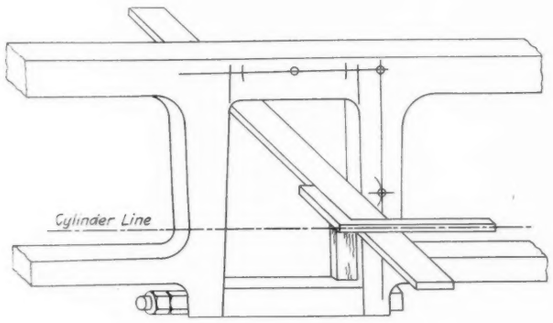


Fig. 1—Laying Out Shoes and Wedges

also the cutting of tire flanges will result. All parts of the engine should fit snug, but go into place without strain.

Improperly located springs, saddles and boxes cause a great deal of unnecessary wear and friction. Strong evidence of this is to be found in any repair shop. Glance at the outside face of the boxes; some are worn on top, and some on the bottom sides, which also indicates unevenly worn brasses. Examine the saddle seats on top of the boxes, and in many cases they will be found to be uneven and not square with the planed surface of the box. While in many cases the spring hangers and saddles are machined and fitted in accordance with a blue print, there will probably be as much difference in the thickness of some of the brasses as ½ in. This is an error that should not go by unnoticed, as it will not allow each box to carry the weight assigned to it, and is an additional cause for friction.

The wheels should be properly quartered. The writer has found some of them out as much as ¼ in. and doing business. Longer side rod journals than is the general practice is recommended as the longer the bearing the less friction. It would be well to provide some way of lubricating the bearing in the truck center casting, perhaps by means of a grease plug tapped in at the most convenient place on side. Some sort of a roller bearing for the center casting would also reduce friction.

Careful attention should be paid to the alinement of the guides, both transversely and in a horizontal direction. This is to take care of undue friction in piston packing and piston rings. There is no doubt that if this is done as it should be the life of the rings, packing and piston rod will be extended.

The valve motion should be gone over carefully, in order not to have too much lead and to see that as much steam is used on one side of the engine as on the other. Any great distortion in the use of the steam, even though the valves are square, will cause a jerky motion and endanger the frames.

The report is signed by B. F. Harris, chairman of the committee.

ELECTRIC ARC WELDING*

BY E. WANAMAKER
Electrical Engineer, Rock Island Lines

The ability of the railroads to meet the demands upon their transportation facilities will be an important factor in the time required for the nation to become effective on the battle fronts. This discussion deals with one way of getting more transportation service out of the railway equipment in existence at the present time. Efforts spent in this direction are as patriotic and necessary as can be imagined. The patriotism of the civilians, particularly of the mechanical engineers in railway service, must not stop with the more or less superficial demonstrations of loyalty to the stars and stripes. Those of us who cannot go to the fighting front must use the best of our abilities to get service, "and still more service," to paraphrase Lloyd George's quotation, from the motive power and rolling stock of the nation's railway systems.

The growing possibilities of the welding processes in motive power and rolling stock maintenance have been a source of amazement to every railway man who has come in contact with the practice. In cutting metal the application of the oxygen cutting processes save from 50 to 90 per cent of the time required to perform the operation. Yet in many of our locomotive shops and car yards the old practices are still followed and our man power for this cause has not produced the maximum result.

The welded fastening came down to us from antiquity. The welded fastening has always been looked upon as a stronger joint than the riveted or bolted fastening. As a general proposition the riveted joint, or bolted joint, has a tensile strength which is considerably less than the tensile strength of the original piece, while the welded joint is as strong as the original section. The welded joint, and particularly the butt welded joint made by an autogenous welding process offers greater strength, with a thickness for practical purposes equal to the thickness of the original plate.

There was a time when worn surfaces of the steel parts in a machine made it necessary to scrap those parts. It was only with the introduction of the autogenous welding processes that it became possible to stop this economic waste.

The repair of broken members of a machine has been another important work of the autogenous welding processes. Prior to their introduction certain steel parts could be welded in the forge fire, but the range of the work was very limited and in many cases its cost equal to the cost of a new part. Now, however, with the exception of cast iron parts, the failure of which would bring death and destruction, practically all parts of a machine which break may be safely repaired.

It is my purpose to point out so far as is possible how far these new practices may be utilized on steam railways to enable the railway systems of the country to meet the present emergency in the matter of service demanded from motive power and rolling stock equipment. The first of the new welding processes, which may properly be called autogenous processes, since the welding takes place more or less auto-

*Abstract of a paper before the Western Railway Club.

matically, was the thermit welding process. This process found a wide application in the repair of broken steel parts on the railroads and the saving which resulted from its use, without doubt aggregated millions of dollars.

Welding with the oxygen and fuel gas flame was the first widely used autogenous welding process. Since everyone is more or less familiar with the gas welding process, this paper will deal primarily with the electric welding process and an extended discussion of the gas process will be omitted. It is sufficient to state that at the present moment the essential difference is in the method of producing the heat for welding, rather than in the fundamental principles involved.

There are two kinds of electric arc welding, known respectively as carbon electrode welding and metal electrode welding. In the former an arc is drawn between a carbon electrode and the piece to be welded and the metal to be added fed into the arc in the form of a "melt-bar." This process is not used extensively in railway work, due to the fact that welding may only be done in the horizontal plane in this manner and that the work is in general inferior to that which is possible with the metal electrode process.

The metal electrode process uses, as the name implies, a metal electrode, the arc being drawn between the electrode and the piece being welded. The heat of the arc melts the metal of the piece and the metal of the electrode simultaneously. As the metal of the electrode melts it is drawn across the arc to the molten metal of the piece where a complete and homogenous union is formed, which we call an autogenous weld. I say the metal of the electrode is drawn across the arc rather than that it falls through the arc advisably, since it will flow straight overhead as well as straight downward. The temperature of the arc is extremely high at its center, actually vaporizing the metal to form the visible arc. With the exception of work with certain electrodes (manganese steel and slag-covered electrodes), the electrode is always made the cathode or negative—that is, the current of electricity flows from the piece being welded to the metal electrode. The reason for this practice is that the greatest amount of heat in an electric arc is liberated at the point at which the current passes from the solid medium to the heated vapor of the arc. Since the metal of the piece has more mass and conducts the heat away from the point at which the welding is being done more rapidly than the electrode, it is desirable to have the greatest amount of heat on the piece. Due to the composition of the manganese and slag-coated electrodes, it is necessary to make these electrodes the positive.

The voltage required for metal electrode welding is approximately 20 volts and direct current power is necessary. The various types of welding equipment are merely different plans for rendering available a rather heavy current at this voltage, and the power economy of the several systems for obtaining this result varies over a wide range.

The successful application of the arc welding process requires the combination of three factors—engineering knowledge, craftsman's skill, enthusiasm. The direction of the practice on our road rests with the engineering staff of the mechanical department; the actual operation is done by skilled members of the boilermakers', pipefitters', machinists' and blacksmiths' crafts. We do not employ novices or apprentices in this work. Only the best men of the respective crafts are picked for operators. It has been plain from the start that only the highest type of craftsmen could secure the results we want and we have witnessed the growth of a considerable amount of pride and enthusiasm in the work among our operators. Even with the best of equipment and facilities for welding, we recognize the fact that it is absolutely necessary that only skilled operators be employed.

Under competent direction, the skilled and enthusiastic operator will seldom make serious blunders in the application of the process. I am quite certain some roads have had great difficulties in this line among operators made of green apprentices and "handy men." Further, we have found that the skilled craftsman, who is enthusiastic is continually finding new and profitable fields for its application.

Comparison of Electric Welding vs. Old Methods and Gas Welding

Description of parts	Cost old method	Cost gas welding	Cost elec. welding	Saving over old method	Saving over gas	No. engs.
Valve stems	$16.28	$15.26	$4.76	$11.52	$10.50	6
Eccentric straps	17.95	7.63	2.38	15.57	5.25	2
Cylinder cocks	1.36	1.04	.34	1.02	.70	1
Cross heads	356.40	120.23	37.73	318.67	82.50	13
Piston heads	47.93	32.74	10.24	37.69	22.50	4
Motion saddles	8.32	10.94	3.44	4.88	7.50	2
Frame braces	99.50	48.00	15.00	84.50	33.00	10
Crank arms	18.81	26.14	8.14	10.57	18.00	5
Rocker box castings	4.59	7.29	2.04	2.55	5.25	1
Transmission bar	2.80	4.38	1.38	1.42	3.00	2
Reach rod	1.25	1.09	.34	.91	.75	1
Rocker arms	20.75	13.24	4.24	16.51	9.00	6
Eng. truck equalizers	7.70	17.24	5.24	2.46	12.00	2
Truck frame	15.70	13.04	4.04	11.66	9.00	3
Trailer jaws	2.76	4.38	1.36	1.40	3.02	1
Extension piston cross head	6.30	4.36	1.36	4.94	3.00	1
Brake beams	1.69	2.18	.68	1.01	1.50	1
Brake hangers	5.10	7.45	3.40	1.70	4.05	3
Smoke arch brace	3.50	6.25	2.14	1.36	4.11	1
Air pump valves	2.50	1.33	.53	1.97	.80	1
Lugs on valve yoke	32.45	21.80	6.80	25.65	15.00	6
Push car wheels	6.00	10.56	3.05	2.94	7.50	4
Stilson wrench	1.60	1.09	.34	1.26	.75	1
Drill chuck	15.00	2.18	.68	14.32	1.50	1
Driver brake fulcrum	5.52	8.72	2.72	2.80	6.00	1
Wheel spokes	1,276.80	113.08	35.08	1,241.72	78.00	15
Main rod blocks	15.88	28.34	6.84	7.04	19.50	9
Triple valve gage	20.00	3.27	1.02	18.98	2.25	1
Link blocks	72.24	51.49	15.49	56.75	36.00	20
Lift shafts	23.98	4.02	1.02	22.96	3.00	1
Quadrant	7.43	11.09	3.59	3.84	7.50	3
Wedges	55.04	69.69	21.69	33.35	48.00	25
Chafing castings	8.30	10.70	3.20	5.10	7.50	1
Plugging and building up holes	349.69	280.94	140.47	209.22	140.47	70
Tire rim keys	3.22	5.38	2.38	.84	3.00	2
Throttle stem	1.50	1.09	.34	1.16	.75	1
Reverse lever support	3.38	4.36	1.36	2.02	3.00	2
Smoke box	61.38	32.43	9.93	51.45	22.50	2
Hub liners	12.51	13.11	4.11	8.40	9.00	3
Strip on cross heads	25.32	31.00	12.66	12.66	18.34	3
Fire door handle	1.75	1.09	.34	1.41	.75	1
Boiler casings	63.21	30.30	9.32	53.89	20.92	1
Frame buckle	4.90	2.41	.91	3.99	1.50	1
Trailer yokes	5.25	6.45	1.95	3.30	4.50	1
Motion frame	9.10	10.17	4.17	4.93	6.00	1
Combination lever	1.03	1.75	.55	.48	1.20	1
Lugs on trailer hub	4.50	4.52	1.52	2.98	3.00	2
Center castings	76.81	28.56	9.06	67.75	19.50	3
Spring blocks	1.15	1.09	.34	.81	.75	1
Guide blocks	5.52	4.29	1.29	4.23	3.00	1
Binder	5.19	13.10	4.10	1.09	9.00	2
Steam pipes	3.79	5.12	2.12	1.67	3.00	1
Flat spots on tires	59.86	95.77	29.77	70.09	66.00	4
Cylinder bushings	35.65	9.40	3.40	32.25	6.00	1
Building up side rods	93.48	81.16	31.16	62.32	50.00	2
Grease cups	11.79	11.43	3.93	7.86	7.50	5
Stationary fire door	8.00	8.72	2.72	5.28	6.00	1
Cracks in tanks	372.69	113.62	35.16	337.53	78.46	14
Petticoat pipes	140.52	52.37	16.37	124.15	36.00	18
Filling worn spots	2,677.80	1,064.60	329.60	2,348.20	735.00	128
Pins	70.66	87.23	27.23	43.43	60.00	27
Reverse lever parts	103.02	74.04	23.04	79.98	51.00	38
Total	$6,434.10	$2,755.74	$921.61	$5,512.49	$1,834.13	

Comparison of Electric Welding vs. Other Methods

Description of parts	Cost of other methods	Cost of elec. weld	Saving	No. engs.
Pedestals	$645.00	$45.24	$599.76	5
Tank frames	9.03	1.36	7.67	1
Shop tools	34.36	3.40	30.96	4
Piston rods	78.64	16.37	62.27	10
Sharp flange drivers	165.40	20.28	145.12	3
Truck side	194.00	10.20	183.80	4
Building up dr. axles	121.50	4.90	116.60	1
Steel car underframe	11.34	1.71	9.63	1
Building up car axles	315.00	25.24	289.76	..
Bushing staybolt holes	294.96	73.74	221.22	26
Welding flues	2,607.65	521.53	2,086.12	102
Frames	931.00	133.28	797.72	11
Cracks in fire boxes	2,431.27	297.17	2,134.10	92
Total	$7,839.15	$1,154.42	$6,684.73	

Summary—Costs and Savings Per Month

Cost of other methods	Cost of gas welds	Cost of electric welds	Saving over other methods	Saving over gas weld
$6,434.10	$2,755.74	$921.61	$5,512.49	$1,834.13
7,839.15	3,697.42*	1,154.42	6,684.73	2,543.00*
$14,373.25	$6,453.16	$2,075.03	$12,197.22	$4,377.13

Costs and Savings Per Year

$77,209.20	$33,068.84	$11,059.32	$66,149.88	$22,009.56
94,069.80	44,369.04*	13,853.04	80,216.76	30,516.00*
$171,279 00	$77,437.88	$24,912.36	$146,366.64	$52,525.56

*Figures show cost of gas weld if work could have been welded with gas.

The connecting link between the engineering staff and the operators is the supervisor of welding, who is fully informed on the range of approved applications and is also the most expert operator on the road. He is continually traveling between the shops keeping the practice of each up to date and seeing that everything runs smoothly. The operators at local points are under the supervision of the foremen and master mechanics in exactly the same manner as lathe operators or other craftsmen.

It was found essential that we compile a complete set of welding instructions, which comprise some thirty typewritten pages. It is the purpose of this set of instructions to standardize the major operations as far as possible. The extreme range of the application of the process has made it quite impossible, up to the present time, to standardize every single operation, but these instructions cover the field in such a general way that the operator is prevented from making serious welding blunders.

The actual results of the operation of the welding equipment and the welding system on the Rock Island Lines have proven very interesting. We have recently undertaken a rather extensive investigation of what the results are, and I am giving below some of the figures we have obtained as a result of about six months' operation of the complete system. The real answer to the question of whether or not the expenditure of some $40,000 for the installation of the system was justified lies in the actual facts—reduction of maintenance cost and actual gain in engine days with our present equipment. The following table shows some actual figures on the cost of repairing a small number of representative locomotive and other parts (for which we were able to obtain costs at a reasonable expenditure) by the gas and electric method, as compared with the old method, which in many cases involves a complete replacement of the part. As compared with the old method, the saving of the electric process arises principally in the saving in labor. As compared with the gas process, the electric welding offers a saving in cost of producing heat and an appreciable saving in cost of labor.

Our figures show that the saving effected by the electric arc welding system is being made at the rate of approximately $200,000 a year with our present equipment. This figure includes a direct saving as compared with other methods of about $136,000. The saving arising from the fact that we keep the engines in service a greater proportion of the time makes up the balance of the figure. Our figures show that this saving is being made at the rate of about 1,400 engine days per year.

Another way of looking at the same matter is that by the operation of the electric welding system we have obtained the service of four additional engines, without the additional investment, beyond that required to install the welding system. Four additional engines are worth approximately $200,000. The welding system installed complete cost about $40,000. The cost of operation of the system for a year is approximately $34,000. Figuring the value of the engines at $40 per day, we will pay for the operation of the whole electric welding system and will clear $22,000 from this feature of the operation of the electric welding system alone. However, we made important savings, as are shown in the preceding table, in the repair of parts on engines, where we could not show an actual gain in engine days of service, and this saving amounts to more than twice the saving arising in the increase of the number of engine days of service we get from our equipment. The net return secured on the electric welder investment amounts to approximately 500 per cent per annum. The net cost of the installation and equipment per unit under present conditions is approximately $1,300. The foregoing figures show rather conclusively that the installation of the electric welding system has been a profitable investment on the Rock Island Lines.

In spite of the fact that we have probably a larger number of operators than any of the Western roads, we believe that we are far from fully equipped. The field of application of the process is continually widening. We are not able at the present time to handle all the operations which we have demonstrated to be practical and profitable. There is a totally unexplored field in maintenance of freight and passenger cars.

Within the last three years the arc welding process has been greatly improved and developed, both in the equipment for making the weld and in the welding material. It has, in fact, been developed to such a state that it will no doubt cause changes in many forms of construction, and the welding of fire boxes, tanks, etc., will become an economical practice. In the field of car construction and maintenance we may look for a wonderful development. For instance, today the cast steel truck side frame will last almost indefinitely where the electric welder is used in maintenance. By the intelligent application of spot welding with the electric arc, it will, no doubt, be possible to tie down bolts and nuts in the various parts of the rolling stock and motive power in such manner as to prevent their working loose, with the attendant very large saving in maintenance and operating expense. Quite recently we have been able, by using what is called a slag-coated electrode, to deposit steel having a carbon content of .50 per cent, which will enable us to do some work which we have been unable to do heretofore. We can successfully take care of the worn or damaged flanges of driving wheels, and should be able to reclaim much of the special work and rail steel by successfully building up the worn parts or broken sections.

It has been our purpose in establishing the practice in the welding field to look the facts squarely in the face and apply either the gas or electric process, depending on which shows the best results at the lowest price. At the present time we are of the opinion that the electric process will supersede the gas process on all steel welding and some of the rough steel cutting. In the cutting of boiler steel and all close cutting, however, and the welding of cast iron and the non-ferrous metals, the gas process has unequaled advantage. We are operating 75 gas torches and 1 acetylene generating plant on the same general principle as obtains in the case of the electric arc welding equipment. It is also best to use gas welders at all points where only occasional welding is done and which would not justify the investment necessary for the installation of an electric welder.

It is our belief that with approximately five times the amount of electric welding capacity we have at present, we can show at least five times the annual net saving, which would amount to a million dollars a year, and that we can with this equipment in operation show a saving of around 7,000 engine days per year, which means that we would be able to secure from our present engines a mileage that will equal that which could otherwise only be secured by the purchase of 23 additional engines.

DISCUSSION.

While many roads reported large savings by the use of oxy-acetylene welding only, a few had installed the arc welding process. The field for electric welding is even wider than for gas welding. Contrary to the opinion generally held, cast iron can be welded by the electric process with success. In judging the efficiency of welding, consideration should be given to the elasticity of the metal in the weld as well as the tensile strength. Welding can be done with thermit where other processes prove unsuccessful; for instance, the welding of main and side rods with thermit was practiced with entire success up to the time when the locomotive inspection law, forbidding autogenous welding of such parts, went into effect.

[Note.—The electric welding equipment of the Rock Island was described in the *Railway Mechanical Engineer* for June, page 307.—EDITOR.]

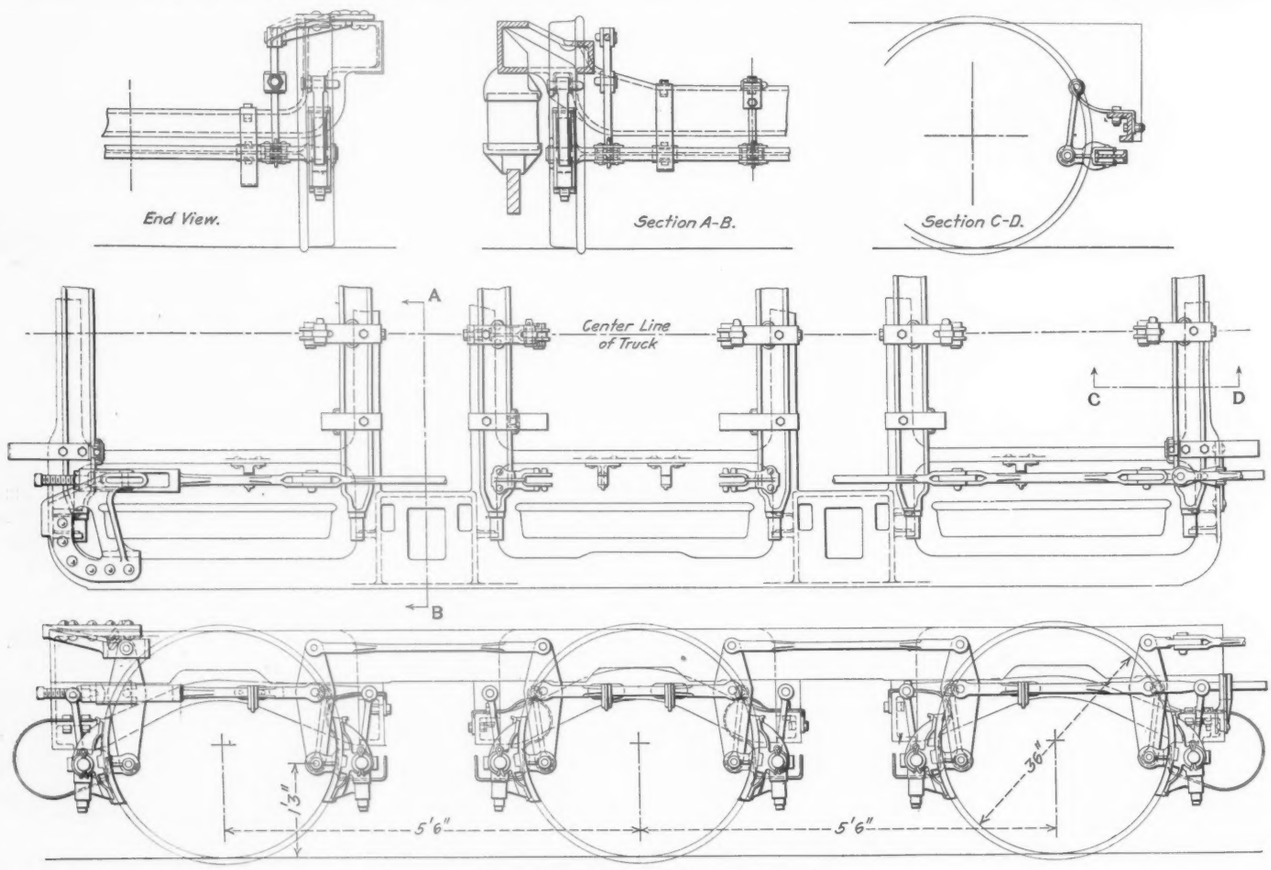
NEW DEVICES

SIMPLEX CLASP BRAKE

A clasp brake adapted for use on either four-wheel or six-wheel passenger car trucks is being manufactured by the American Steel Foundries, Chicago. The design has been worked out with a view to providing a truck foundation brake gear that would perform its function in the most efficient manner without sacrificing simplicity, strength and economy of maintenance.

The brake rigging as applied to the truck consists of a double system of vertical levers just inside the wheels, connected to one another through pull rods and to the brake beams through fulcrum jaws. The brake beams, which are suspended close to the horizontal center line of the wheels, are straight drop forged members of an I-section, with cylindrical brake head trunnions at both ends. Brake hangers pivoted to the truck frame on both sides support the brake beams at the heads. The brake beams have a third point of support at the center where a fulcrum jaw is fastened. This is connected to a swing hanger suspended from a spring steel bracket bolted to the truck frame. The brake beams in turn support the levers and thus all movement and support of the rigging is taken care of by swing hangers.

The adjustable brake heads, which are mounted on the trunnions, are of a special design to give the maximum space for changing shoes, at the same time affording ample clearance between the brake beams and the flanges of the wheels. Bearings for the release springs are fastened to the brake beams to prevent chafing of the beams. Adjusting screws are provided at the outer ends of the truck and give sufficient movement to adjust the entire rigging, which is necessary only when variations are made in the diameter of the wheels. All moving connections are case-hardened to keep the lost motion in the rigging to a minimum.



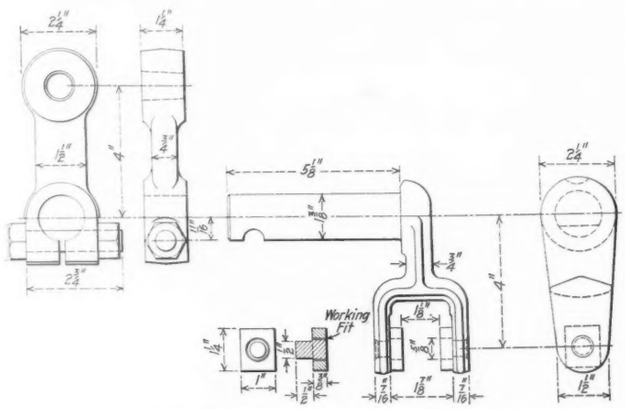
Arrangement of the Simplex Clasp Brake

The type of construction used in the Simplex clasp brake produces an even distribution of forces on all shoes. Inertia

has been reduced by providing the most direct method of transmitting braking force and by keeping the weight of the parts as low as possible consistent with strength. Friction has been minimized by the swing hanger method of support. Since the rods all pass over some part of the truck it is practically impossible for any parts of the rigging to fall to the track. The design has been thoroughly tested by the American Steel Foundries and is in extensive use.

TYPE "B" RAGONNET REVERSE GEAR

On the accompanying drawing is shown the general arrangement of the "Type B" Ragonnet power reverse gear. This gear has recently been brought out by the Economy Devices Corporation, New York, and is a modification of



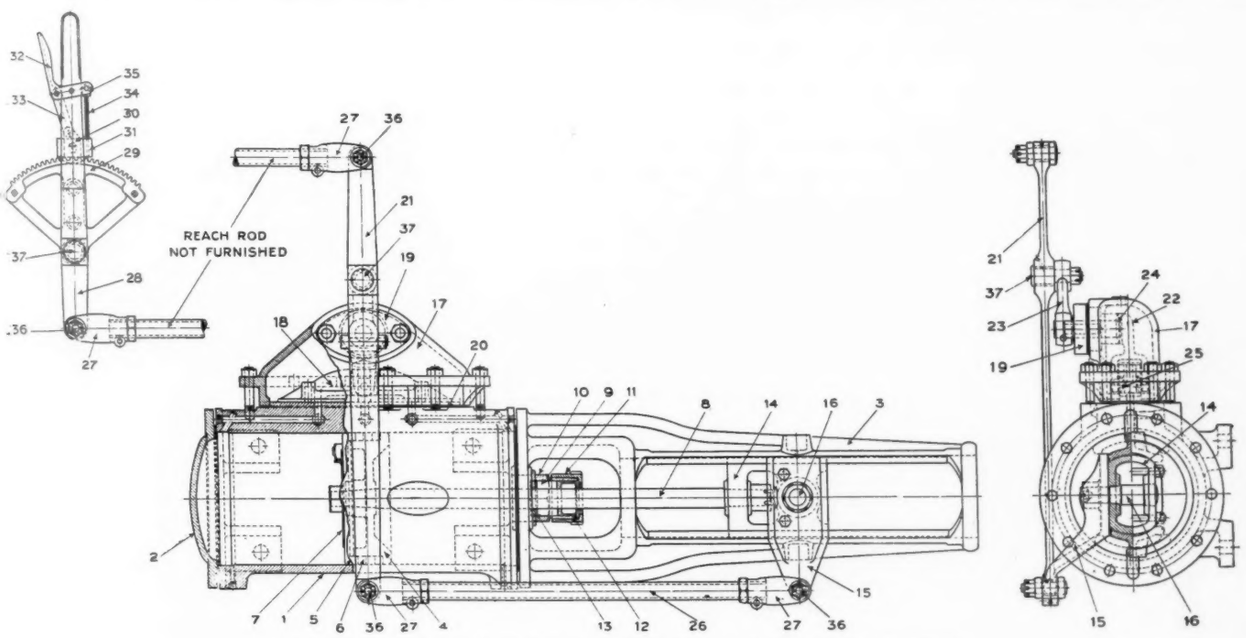
Details of the Valve Rocker and Connections

the well known Ragonnet reverse gear now in extensive service.

The most noticeable modification in the gear is the method by which the combination lever is connected to the slide valve, which materially decreases the length of the crosshead arm and raises the lower end of the combination lever so that there is practically no projection below the reverse gear cylinder. A slide valve, modified in detail from that used in the older gear, has been retained and the method of lapping the valve and maintaining air pressure in the cylinder is the same in principle as that previously employed. The mechanical connections, however, have been entirely changed and the gear possesses a number of operating features impossible of attainment with the older design.

Starting at the cab, it will be seen that the lower end of the reverse lever is connected to the top of the combination lever, while the crosshead arm and the lower end of the combination lever are joined by a connecting rod. The valve is operated by a rocker extending out through the valve chest gland 19, the end of the outside rocker arm being attached to an intermediate pin connection in the combination lever. For any position in which the reverse lever may be latched, it will be seen that the valve is lapped when the piston has moved to a position in the cylinder corresponding to the position of the reverse lever. In this respect the operation of the "Type B" gear is the same as that of the previous type.

The construction of this gear is such, however, that the position of the reverse lever must always correspond within one or two notches to the position of the block in the link, irrespective of whether or not air pressure is available for the operation of the gear. This is brought about by extending the ends of the slide valve so that its movement in the valve chest is limited in either direction to the amount necessary to bring the cylinder port in line with the adjoining air admission port through the valve. A slight movement of the reverse lever causes the end of the valve to strike the end of the steam chest and prevents any further movement of the lever until the piston moves in the cylinder. The rocker arm connection 37 in effect becomes the fixed pivot, and the further movement of the reverse lever can only take place at a rate proportional to the movement of the piston in the cylinder. Should there be a tendency for the blocks to drop in the links when the engine is standing with the air pump shut off, excessive stresses might be set up in the parts of the gear if the valve and combination lever were depended upon to resist this movement. In order to protect the gear under such conditions the reverse lever latch is so arranged that the force transmitted to the reverse lever lifts from the notches in the quadrant, thus permitting the lever to follow the movement of the link block to the corner.



General Arrangement of the Type "B" Ragonnet Power Reverse Gear

When the valve chest is again under pressure, no movement of the gear is possible beyond the slight amount necessary to lap the valve until the reverse lever is moved.

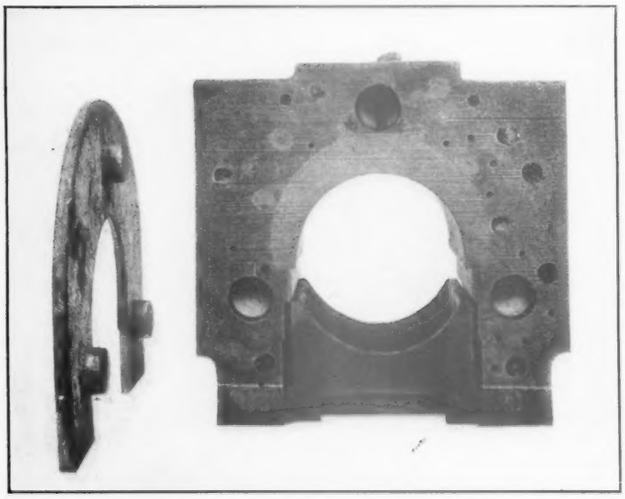
In the construction of the cylinder and valve, cored passages have been entirely avoided, thus eliminating any possibility of trouble from coarse sand or scale at the valve seat. The increase in the length of the valve has materially added to the bearing surface and decreased the tendency toward uneven wear. Uniformity of wear is also insured by bringing the point of drive down close to the seat. The cylinder ports in the valve seat require an exhaust cavity in the valve but one-half inch in width and, therefore, the unbalanced area is so small that the valve always moves freely.

The parts inside the valve chest have been so arranged that there is nothing that can work loose or become displaced after they have once been assembled. The valve is moved by means of square blocks, which are placed on the inside of the jaws of the rocker, 22. These blocks work in vertical slots in the sides of the valve, and are pivoted about the ends of pins riveted in the rocker jaws. This construction will be made clear by reference to the drawing of the rocker. The rocker shaft is guided by the valve chest gland, 19, through which it has a working fit. This gland is made steam tight by the use of a ball joint ring, 24, which seats against the end of the gland, the flat face bearing against a shoulder on the rocker. The joints are sealed by the pressure in the valve chest.

The piston is packed with a special type of packing which has been developed especially for that purpose. Each ring is made up of a special rubber core which will not vulcanize under the saturated steam temperatures met with in locomotive practice, and which is not affected by oil. Outside of this core the ring is made up of a duck fabric arranged in vertical layers, so that the edges of the material form the wearing surface. Three of these rings are placed in each piston and are held in place by a follower plate, the edge of which bears directly against the packing. The guides are of the bored type, and are cast integral with the front cylinder head, thus making them self-centering.

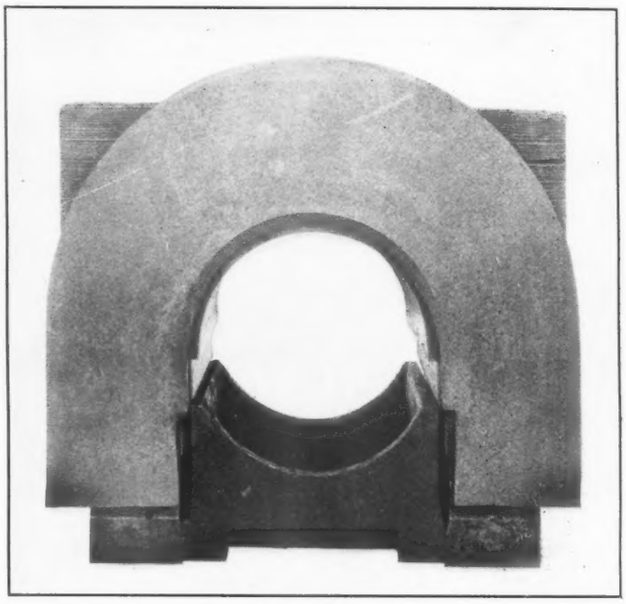
A REMOVABLE DRIVING BOX HUB LINER

A removable hub liner for locomotive driving and engine truck boxes has been patented by J. T. Mallard, and its application is being handled by the Mallard Hub Liner Company, Newbern, N. C. This liner is made in two styles, one for use on roads where considerable curvature is encountered and the other for use where the line is comparatively straight. The illustration shows the application of the latter type.



The Hub Liner Removed from the Box

As will be seen from the photograph, the brass hub liner is cast with three lugs of circular section on the back face, the diameters of which are 2¼ in. The face of the box is planed off to provide a bearing for the liner and holes are drilled at the proper locations to receive the lugs on the liner. A hole for a ¼-in. pin is drilled in the top lug and a corresponding hole is drilled through the driving box casting in order that the liner may be held in place by the use of a ¼-in. pin.



The Mallard Hub Liner

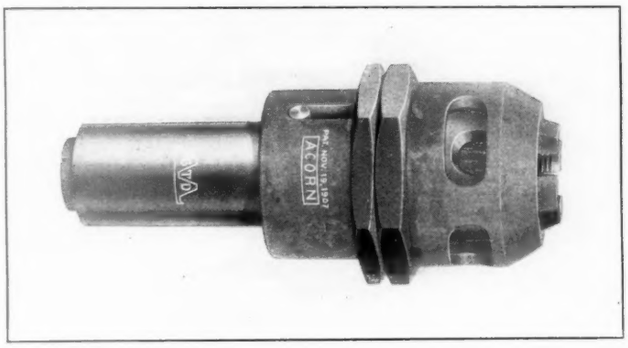
The type of liner used where considerable curvature is encountered differs in the shape of the lugs which fit into the face of the driving box. These are oblong, the exact dimensions depending somewhat upon the design of the driving box. The upper lug is placed horizontally and ordinarily measures about 7½ in. long by 1½ in. wide, the ends being semi-circular in shape. The two side lugs are placed vertically and are about 4 in. long. The liner is secured to the box by two pins, one being placed through the top lug near each end.

It will be seen that the liner covers the entire face of the driving box, thus affording a bearing for practically the full area of the driving wheel hub. This is of advantage in that it distributes the wear over a larger area. After the first application of the Mallard liner, which should be made at the time the engine goes through the shop, the lateral may be taken up in from two to three hours for each pair of wheels. With liners poured on the face of the driving box, the taking up of lateral has always involved the shopping of the locomotive, it being necessary to take down the rods and drop the wheels in order to remove the driving boxes and apply new liners. With the removable liner it is only necessary to take down the pedestal binder, drop the shoe and wedge and move the box over against the pedestal. This allows sufficient clearance between the box and the wheel hub to remove the liner and replace it with a new one. It is not absolutely necessary that the liners be pinned to the boxes, as there is insufficient clearance between the face of the liner and the driving wheel hub with the shoe and wedge in place to permit the removal of the liner lugs from the pockets in the face of the box. Their use is desirable, however, to prevent undue pounding of the liner between box and hub.

ACORN DIE AND HOLDER

A die and holder has recently been developed by the Greenfield Tap & Die Corporation, Greenfield, Mass., which permits of adjustment without in any way impairing the accuracy of the lead. The die is also so designed that it may readily be removed from the holder and reground.

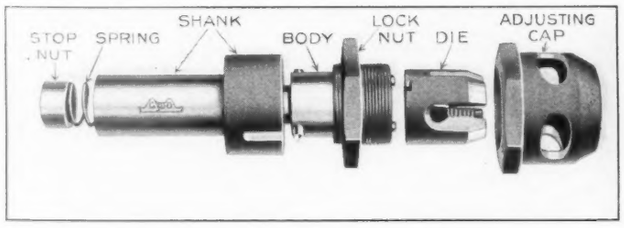
By referring to the dissembled view of the die holder, it will be seen that the die is secured to the holder by an adjusting cap which fits over the die and is threaded onto the body of the holder. The cap is provided with holes in the walls to permit the exit of chips which may collect inside the base of the die. The adjusting cap is secured to the body in any desired position by a nut lock. The nose of each die is



The Acorn Die and Holder Assembled

beveled to an angle corresponding to that on the inside cone of the adjusting cap. Both beveled surfaces are ground, thus assuring perfect contact and accuracy of adjustment. The radial adjustment of the lands is accomplished by turning the adjusting cap on the thread of the body, the bevel on the inside of the cap exerting a uniform pressure upon all the lands and drawing them together to whatever diameter may be required. It is evident that the lands are moved radially and that their angular spacing is unaffected by the adjustment, a condition which does not hold for either the round split die or dies in which the prongs are held in a split ring. The tracking of the lands, therefore, always remains perfect.

The body, the stem of which is inserted in the shank, is

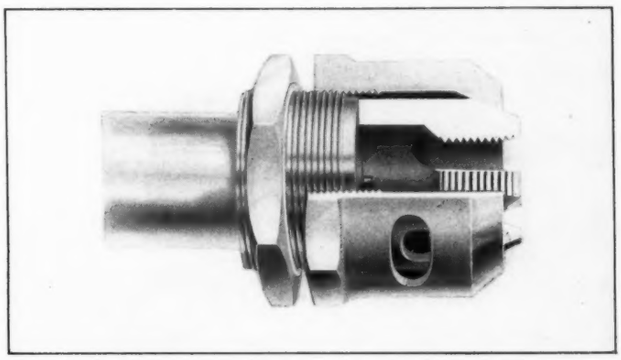


Dissembled View of the Acorn Die Holder

of ample dimensions to provide for any operating strain that may be brought to bear upon it. The body is driven by means of a cross pin which fits into the slot in the shank. The body is not held rigidly in the shank, but is permitted a certain degree of lateral slide or "float."

The lands of the Acorn die are somewhat similar to those of a spring die, but are shorter and wider. Their strength is such that there is no tendency for them to twist. The use of a special alloy steel in their manufacture permits their successful hardening without distortion. In order to facilitate the necessary radial movement of the lands, the section immediately back of the thread is reduced in thickness. The lands are of uniform strength, however, owing to the increased width at the base; this prevents any tendency toward torsional displacement.

Notches in the base of the die register with dowels on the body, thus securing a positive drive. The base of the die and its seat on the body are accurately ground to a flat surface, which insures absolute alinement when changing the dies or replacing them after sharpening. The opening between the lands facilitates the grinding the dies, which may



Sectional View of the Die and Adjusting Cap

be done by hand or by machine, in a special holder.

The illustrations show the regular Acorn die holder, but releasing holders or adapters, by means of which the Acorn dies may be used in machines or holders already in operation, may be supplied.

CAST STEEL PILOT AND ASH PAN

Among its several products the Commonwealth Steel Company, St. Louis, Mo., has had in successful service cast steel pilots and ash pans. The pilot is shown in Fig. 1. It can be quickly applied, removed, raised or lowered, one means provided for raising or lowering it being a rack. This construction permits the alteration in height to be attained in a few minutes. These racks on the backs of the pilots are

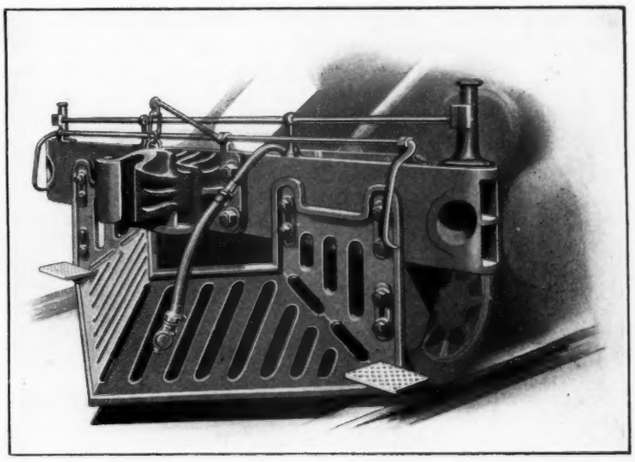


Fig. 1—Commonwealth Cast Steel Pilot

made to fit corresponding racks on the pilot beams, or on separate brackets fastened to the pilot beams.

These adjustable pilots are cast in one piece and can readily be made to meet the requirements of new or old locomotives. They are strong, simple and durable, requiring practically no repairs, and in time make quite a saving in maintenance cost, as compared with other types. They are easily repaired when bent in case of wreck. One of the designs embraces the requirements for both road and switch

engines, a long step being placed at either side to meet switch engine requirements when a road engine is used in yard switching. They meet all Government requirements.

The cast steel ash pan is shown in Fig. 2. It is made for single and double hoppers. These ash pans do away with the frequent expensive renewals and repairs characteristic of other types, as they are so designed that they do not burn out. They also prevent live coals from scattering on the roadway and causing fires. As these pans do not warp,

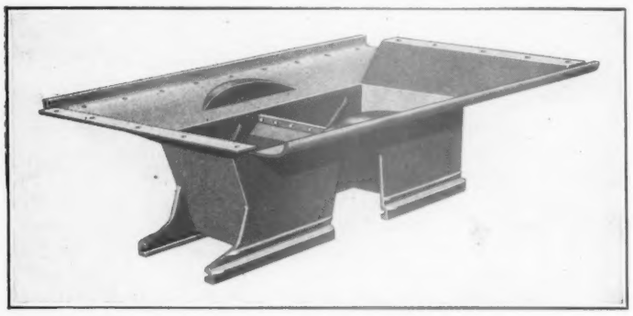


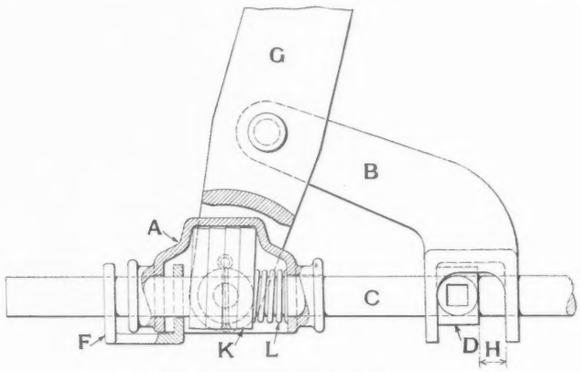
Fig. 2—Commonwealth Cast Steel Ash Pan

a tight door is maintained that retains the coals. They are made up of but a few parts and have that advantage over the built-up types. This type of pan will last a long time and greatly reduces the maintenance costs for this particular part of the locomotive.

TRUCK LEVER TYPE SLACK ADJUSTER FOR FREIGHT CARS

In the June 14, 1916, issue of the *Daily Railway Age Gazette,* page 1263, there appears a description of an automatic slack adjuster for freight cars which was developed by the Gould Coupler Company, New York. This slack adjuster replaced the push rod in the truck brake rigging, performing the functions of the latter, as well as that of the slack adjuster. The function of the push rod was performed by two members, one of which telescoped within the other. In the barrel, or hollow member, was a pocket containing two friction grip dogs through which passed the solid, or push rod member, the normal position of the dogs at an angle of four or five degrees from a line at right angles to the center line of the push rod preventing the latter from telescoping, but permitting its movement freely in the other direction to lengthen the connection between the lower ends of the live and dead levers. An adjusting rod attached to the brake beam fulcrum pin of the live lever, provided with a friction sleeve operating between two lugs on the side of the barrel member of the slack adjuster, automatically caused the lengthening of the push rod members on the release of the brakes to maintain a constant clearance between the brake shoes and the wheels.

The drawing shows the application of the same principle in a device, since developed by the Gould Coupler Company, which has been materially altered and much simplified in construction. The slack adjuster proper is attached directly to the lower end of the live lever and through it passes the push rod which in this case is in one piece. The friction

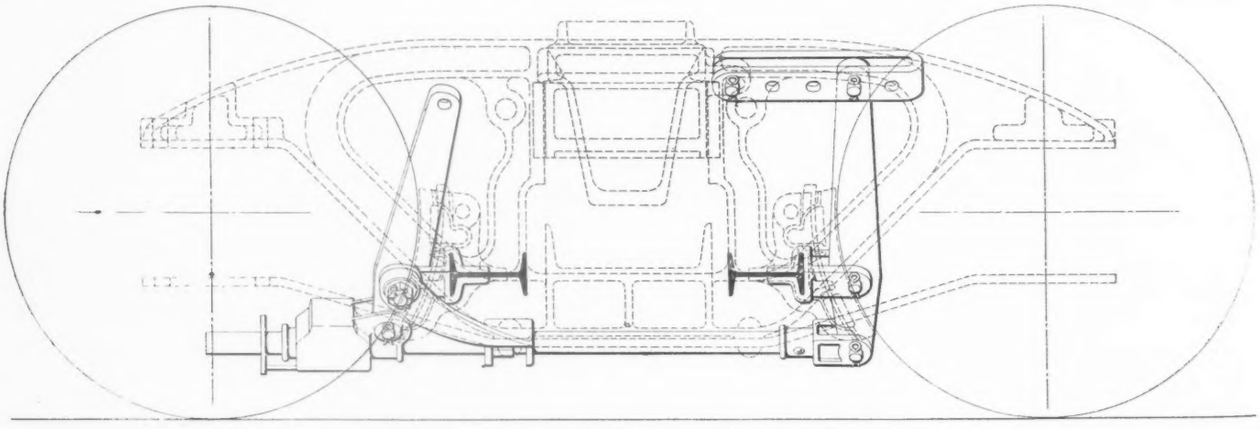


Details of the Slack Adjuster

sleeve is mounted directly on the push rod and the adjusting rod employed in the original device has been replaced by an adjusting bracket attached to the live lever at the same location, but provided with a housing at the other end which slides on the push rod and contains the friction clamp.

The operation of the slack adjuster may be made clear by referring to the sectional drawing showing the arrangement of the details. It will be seen that the slack adjuster body *A*, containing four clamping dogs *K* is mounted on the push rod *C*, the lower end of the live lever *G* being connected directly to the body *A*. The spring *L* normally holds the dogs *K* in an oblique position in which they grip the push rod and prevent any movement of the adjuster along the rod toward the right. The friction clamp sleeve *D* may be moved along the push rod, but considerable pressure is required to move it.

The device as shown in the drawing is in release position. An application of the brake causes the upper end of live lever *G* to move to the left, carrying with it its brake beam and brake shoes until the latter bear against the wheel treads. Further movement then causes the push rod *C* to be moved to the right, applying the brake shoes to the other



Universal Truck Lever Type Automatic Slack Adjuster

pair of wheels. The distance *H* between the friction clamp and the right hand shoulder of the adjusting bracket *B* is just sufficient to permit the angular movement of the live lever relative to the push rod required to take up the normal amount of clearance between the brake shoes and the wheel treads.

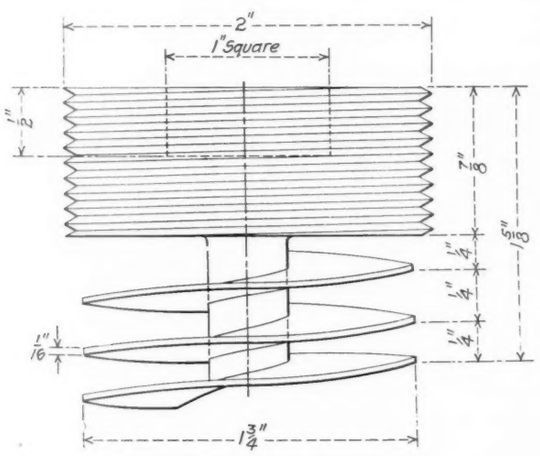
Any increase in this clearance due to brake shoe wear causes the shoulder of the adjusting bracket to move the friction clamp along the push rod toward the left. On the release of the brake, the parts again assume the position shown in the drawing, the left hand shoulder of the adjusting bracket striking the friction clamp *D* and, if the latter has been moved to the left in the preceding brake application, causing the push rod *C* to move to the right through the slack adjuster jaw by the same amount. The slack will thus be taken up and only a normal amount of movement of the parts will take place at the next application of the air brake.

When the brake shoes are renewed it becomes necessary to let out the slack. To do this, the release handle *F* is first moved to the right, thus unlocking the dogs *K* and permitting the push rod *C* to move to the left. The friction clamp *D* is forced to the right until it strikes the right hand jaw of the adjusting bracket, this operation being repeated until the brake beams are far enough off the wheel to renew the brake shoes. The proper adjustment of brake shoe clearance will automatically be effected on the first application of the brake.

MASON GREASE CUP PLUG

A new form of grease cup plug which is being used with good results is shown below. As will be seen by referring to the illustration, the plug is so constructed that it is securely held even though it is screwed in but a short distance.

The design is particularly effective when used with an internally threaded grease cup. It frequently happens that after grease cups are freshly filled, the plugs cannot be screwed into the cups more than three or four turns, which does not furnish a sufficient engagement for the plug and it is dislodged by vibration. It is claimed that with

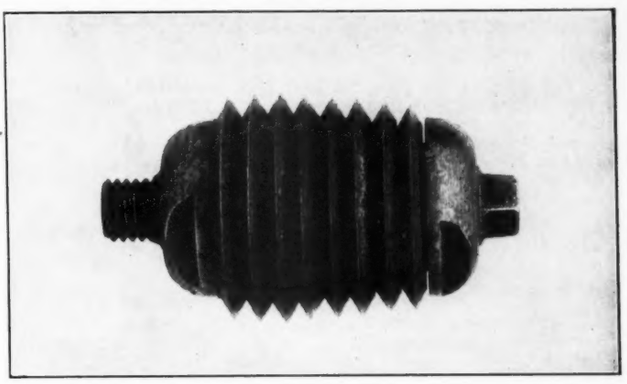


Mason Grease Cup Plug

this type of plug dislodgment is prevented by reason of the fact that when the cup is filled with grease and the plug screwed into place a certain amount of the grease is forced around the screw blade, holding the plug in position. This device has been adopted after extensive tests by one of the large western roads. The plug has been patented by the inventor, Fred Mason, Pittsburg, Kan.

ARCH TUBE CLEANER

The arch tube cleaner shown in the illustration has been patented by R. M. Clark, foreman of the Nashville, Chattanooga & St. Louis, and has been used on that road with considerable success. This tool is made of substantial material and is composed of a hollow spindle and eight round



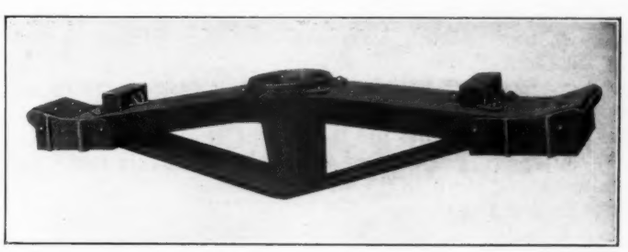
Tool for Cleaning Arch Tubes

cutters. The cutters are made of steel and are tempered hard. The tool is lubricated with hard grease and is ready for service at all times. It can be attached to any turbine motor and will remove the hard scale from arch tubes or any kind of tubes successfully.

HUNTOON TRUCK BOLSTER

The Joliet Railway Supply Company, Chicago, has placed on the market a new type of truck bolster known as the Huntoon bolster. It is of the built-up type and embodies the same principles of reinforcing of the tension member that is used in the tension member of the Huntoon brake beam.

Both the compression and the tension members are of open hearth steel, the compression member being a channel and the tension member a flat bar upset at the ends to retain the full cross sectional area at the rivet holes. The ends of the tension member are provided with shoulders which interlock with the web and flanges of the compression member, thus relieving the shearing strain on the rivets.



New Type of Built up Bolster

The king post is of malleable iron of heavy cross section. The center plates can be furnished of malleable iron, cast steel or drop forged, as desired. The bolster is adapted to the application of either plain or anti-friction type side bearings.

Tests have demonstrated that this type of construction produces a bolster of great rigidity and strength. Sizes for 30, 40, 50 and 70-ton cars are now being manufactured and the company is prepared to furnish them in any quantities desired.

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WE GUARANTEE that of this issue 10,000 copies were printed; that of these 10,000 copies 7,861 were mailed to regular paid subscribers, 110 were provided for counter and news companies' sales, 311 were mailed to advertisers, 190 were mailed to exchanges and correspondents, and 1,528 were provided for new subscriptions, samples, copies lost in the mail and office use; that the total copies printed this year to date were 92,347, an average of 9,234 copies a month.

THE RAILWAY MECHANICAL ENGINEER is a member of the Associated Business Papers (A. B. P.) and the Audit Bureau of Circulations (A. B. C.).

A roundhouse of the Delaware, Lackawanna & Western at Scranton, Pa., was damaged by fire September 13, and 14 locomotives were seriously damaged.

The Delaware & Hudson has made a general increase in the pay of shopmen; said to be, for mechanics, from 45 cents an hour to 50 cents, and for helpers from 30 cents an hour to 33½ cents.

The State College of Pennsylvania announces special correspondence courses in elementary engineering subjects, established to meet the unusual demand for men in shops and manufacturing plants.

A strike of shopmen of the Kansas City, Mexico & Orient was settled through mediation on September 14, following conferences between committees representing the shop crafts and officers of the road. The men had asked for a 10-cent increase in wages, and were offered an increase of two and one-half cents an hour by the company. The compromise agreement, which was reached on September 14, provides for an increase of from three to six cents an hour for mechanics, helpers and car-men, and two and one-half cents for apprentices. The men had been off work for nine days.

According to advices received by the Texas Railroad Commission, there is such a shortage of expert mechanics that the Southern Pacific and the Santa Fe are meeting delay in changing the fuel equipment of their locomotives from oil burners to coal burners. The purpose of going back to the use of coal is in order to conserve the crude oil supply for war purposes. The demand for mechanics is said to be the greatest ever known in the history of Texas. Thousands of these skilled artisans have left the state during the last several months to take employment in industrial plants in the North and East. The railroad shops have been largely depleted of this class of employees, and there is no source open by which to fill the existing demand for them.

Recruiting officers in several of the large cities of the country are advertising for recruits for five additional engineer regiments, one of which, the 21st Engineers, will be for constructing light railways. The remaining four include the 20th, forestry; the 23rd, highway; 25th, construction, and the 26th, supply and water supply. For the 21st, the light railway, men trained in the following trades are wanted: Timbermen, bridge carpenters, masons, pipefitters, steamfitters, hoisting engineers, firemen, dinkey runners, teamsters, track layers, construction foremen, pile drivers, concrete foremen, telegraph linemen, riggers, cooks, machinists, blacksmiths, transitmen, surveyors, draftsmen, storekeepers, machine repairers, clerks, electricians, oilers, painters, rod drillers, powdermen, signal installers and bridgemen.

The Missouri, Kansas & Texas management recently came to an understanding with its shopmen with reference to wage increases. The terms of settlement with the men included a flat increase of 6½ cents an hour to machinists, boilermakers, blacksmiths, sheet metal workers and electricians, and to the helpers in the different trades and helper apprentices. Regular apprentices were granted an advance of 2½ cents an hour. The increases make the standard rate of pay for machinists, boilermakers, blacksmiths, sheet metal workers and shop electricians for points north of Muskogee, Okla., 50 cents an hour; for Muskogee and points south, including Oklahoma City and McAlester

RAILROAD CLUB MEETINGS

Club	Next Meeting	Title of Paper	Author	Secretary	Address
Canadian	Oct. 9	Locomotive Design and Construction from a Maintenance Standpoint	W. H. Winterrowd	James Powell	P. O. Box 7, St. Lambert, Que.
Central	Nov. 9	The Handling of Scrap, Etc.	J. P. Murphy	Harry D. Vought	95 Liberty St., New York.
Cincinnati	Nov. 13			H. Boutet	101 Carew Bldg., Cincinnati, O.
New England	Oct. 9	The Freight Car—A Factor in Winning the War	E. H. De Groot	W. E. Cade, Jr.	683 Atlantic Ave., Boston, Mass.
New York	Oct. 19	Conservation of Material	M. K. Barnum	Harry D. Vought	95 Liberty St., New York.
Pittsburgh	Oct. 26	Annual Meeting, Smoker and Entertainment		J. B. Anderson	Room 207, P.R.R. Sta., Pittsburgh, Pa.
Richmond	Oct. 8			F. O. Robinson	C. & O. Railway, Richmond, Va.
St. Louis	Oct. 12	The Ability of Refrigerator Cars to Carry Perishable Freight	Dr. M. E. Pennington	B. W. Rrauenthal	Union Station, St. Louis, Mo.
South'n & S'w'rn.	Nov. 15			A. J. Merrill	Grand Building, Atlanta, Ga.
Western	Oct. 15			J. W. Taylor	1112 Karpen Bldg., Chicago.

and all points in Texas, 51 cents an hour, and on the Wichita Falls & Northwestern, 52 cents an hour. Machinists, steel metal workers and electrician helpers will receive 30½ cents an hour at all points on the system and boilermaker and blacksmith helpers 33 cents an hour.

Headlight Order Again Modified

The Interstate Commerce Commission has announced a further modification of its locomotive inspection rules, postponing from July 1 to January 1, 1918, the effective date of the requirement that new locomotives shall be equipped with electric headlights, and providing that for locomotives in service prior to that date the changes shall be made the first time they are shopped for general repairs after that date. All locomotives are required to be equipped by July

Strike of B. & M. Shopmen

The machinists, blacksmiths and boiler makers of the Boston & Maine struck on August 31, and all the locomotive repair shops, general and division, stopped work, about 3,300 men going out. Nearly half of these men were employed at the shops at Billerica, Mass. Conferences concerning the requests of the men for higher pay have been held a number of times since last April, when an increase of about two cents an hour was granted and was made retroactive from January 1, 1917. In July the men asked for a further increase of eight cents an hour. The New Haven road has recently granted an increase and the receiver of the Boston & Maine offered to make the pay on the B. & M. equal to that on the New Haven, but this was refused. The increase on the New Haven, three cents an hour, brought the rates up to a point a little in excess of the rates on the Boston & Maine. An agreement was reached on September 8 at a conference between the strikers, the railroad officers and the Massachusetts Committee on Public Safety, and the 3,300 men involved are now back in the shops.

Both the union and the railroad agreed that the wages be raised five cents an hour, provided the men return to work at once. The men asked for eight cents an hour, and the remaining three cents will be submitted to an arbitration for decision. Henry B. Endicott, executive manager of the Public Safety Committee, was chosen the sole arbitrator.

MEETINGS AND CONVENTIONS

The following list gives names of secretaries, dates of next or regular meetings and places of meeting of mechanical associations:

AIR BRAKE ASSOCIATION.—F. M. Nellis, Room 3014, 165 Broadway, New York City.

AMERICAN RAILROAD MASTER TINNERS', COPPERSMITHS' AND PIPEFITTERS' ASSOCIATION.—O. E. Schlink, 485 W. Fifth St., Peru, Ind. Convention postponed.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.—J. W. Taylor, Karpen Bldg., Chicago. Convention postponed.

AMERICAN RAILWAY TOOL FOREMEN'S ASSOCIATION.—R. D. Fletcher, Belt Railway, Chicago. Convention postponed.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Prof. E. Marburg, University of Pennsylvania, Philadelhia, Pa.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Calvin W. Rice, 29 W. Thirty-ninth St., New York.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.—Joseph A. Andreucetti, C. & N. W., Room 411, C. & N. W. Station, Chicago.

CAR FOREMEN'S ASSOCIATION OF CHICAGO.—Aaron Kline, 841 Lawlor Ave., Chicago. Second Monday in month, except June, July and August, Hotel Morrison, Chicago.

CHIEF INTERCHANGE CAR INSPECTORS' AND CAR FOREMEN'S ASSOCIATION.—W. R. McMunn, New York Central, Albany, N. Y. Convention postponed.

INTERNATIONAL RAILROAD MASTER BLACKSMITHS' ASSOCIATION.—A. L. Woodworth, C. H. & D., Lima, Ohio. Convention postponed.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.—J. G. Crawford, 547 W. Jackson Blvd., Chicago.

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION.—William Hall, 1126 W. Broadway, Winona, Minn. Convention postponed.

MASTER BOILERMAKERS' ASSOCIATION.—Harry D. Vought, 95 Liberty St., New York. Convention postponed.

MASTER CAR BUILDERS' ASSOCIATION.—J. W. Taylor, Karpen Bldg., Chicago. Convention postponed.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION OF U. S. AND CANADA.—A. P. Dane, B. & M., Reading, Mass. Convention postponed.

NIAGARA FRONTIER CAR MEN'S ASSOCIATION.—E. N. Frankenberger, 623 Brisbane Bldg., Buffalo, N. Y. Meetings, third Wednesday in month, New York Telephone Bldg., Buffalo, N. Y.

RAILWAY STOREKEEPERS' ASSOCIATION.—J. P. Murphy, Box C, Collinwood, Ohio. Convention postponed.

TRAVELING ENGINEERS' ASSOCIATION.—W. O. Thompson, N. Y. C. R. R., Cleveland, Ohio.

PERSONAL MENTION

GENERAL

W. L. BEAN, whose appointment as assistant to the general mechanical superintendent of the New York, New Haven & Hartford, was announced in these columns last month, was born on January 3, 1878, at Stevens Point, Wis., and graduated from the University of Minnesota with the degree of mechanical engineer in 1902. The same year he began railway work with the Northern Pacific as special apprentice. In December, 1904, he went to the Atchison, Topeka & Santa Fe, serving successively as erecting shop foreman, locomotive inspector at the Baldwin Locomotive Works in Philadelphia, and machine shop foreman at La Junta, Colo. In January, 1909, he was appointed division foreman at Belen, N. M., and the following July was appointed motive power assistant at Topeka, Kan. On February 1, 1912, he became chief engineer for the Oswald Railroad Service Company, at Chicago, and on July 10, 1916, he entered the service of the New Haven in the capacity of assistant to the president.

W. L. Bean

WILLIAM H. BRADLEY, who has been appointed assistant to the general superintendent of motive power of the Chicago & North Western, with headquarters at Chicago, as announced in the *Railway Mechanical Engineer* for September, was born in May, 1869, at Momence, Ill. He was educated in the Chicago public schools and began work with the Chicago & North Western on December 1, 1885, as machinist helper. From June 6, 1886, to November 29, 1891, he was a fireman, then becoming an engineman, and in January, 1903, a road foreman of engines. He was promoted to assistant master mechanic of the Iowa division in August, 1907, and in September, 1908, was made master mechanic of the Madison division. In October, 1909, he was transferred to the Iowa division as master mechanic.

W. H. Bradley

H. C. EICH, master mechanic at the Burnside, Chicago, shops of the Illinois Central, has been appointed superintendent of motive power of the Chicago Great Western, with headquarters at Oelwein, Iowa, succeeding G. M. Crownover, resigned.

WILLIAM H. FETNER, general master mechanic of the Central of Georgia at Savannah, Ga., has been appointed acting superintendent of motive power, during the leave of absence of F. F. Gaines.

J. H. FULMOR, master mechanic of the Pennsylvania Railroad at Mt. Carbon, Pa., has been assigned to duty on the staff of the superintendent of motive power, Eastern Pennsylvania division, as inspector, with office at Altoona, Pa. Mr. Fulmor was born in 1874 and received his education in the public schools. On June 9, 1891, he became an apprentice with the Pennsylvania Railroad and on July 1, 1895, was made machinist. On January 16, 1899, he was advanced to acting road foreman of engines and was made master mechanic at Mt. Carbon, Pa., on April 1, 1905.

F. F. GAINES, superintendent of motive power of the Central of Georgia at Savannah, Ga., has been granted a leave of absence on account of illness.

F. N. HIBBITS, who resigned as superintendent of motive power of the Lehigh Valley in 1915, to go to the Baldwin Locomotive Works as assistant general superintendent, has returned to the service of the Lehigh Valley, as superintendent of motive power, succeeding H. C. May, resigned.

L. S. KINNAIRD, master mechanic on the Pennsylvania Lines at Logansport, Ind., has been appointed superintendent of motive power of the Chicago & Eastern Illinois, with headquarters at Danville, Ill., succeeding J. E. Epler, resigned.

PAUL L. GROVE, master mechanic of the Philadelphia Terminal division of the Pennsylvania Railroad, has been appointed superintendent of the Delaware division of the Philadelphia, Baltimore & Washington, with office at Wilmington, Del. Mr. Grove was born on October 3, 1878, at Altoona, Pa., and was educated in the public schools of that city. From May 1, 1894, to December 1, 1899, he was employed by the Pennsylvania Railroad as messenger and machinist apprentice in the Altoona shops. On February 1, 1902, he was transferred to the shops at Columbia, Pa., as inspector, and in October, 1904, became shop foreman on the Bedford division. He was promoted to assistant master mechanic of the Altoona machine shops on July 1, 1905, and was made assistant engineer of motive power on the Buffalo division in September, 1910. He was promoted on December 1, 1913, to master mechanic on the Williamsport division; in October, 1914, he was transferred to the Renovo division, and on July 1, 1916, he was again transferred to the Philadelphia Terminal division, in charge of the West Philadelphia shops, and now becomes superintendent of the Delaware division.

P. L. Grove

H. C. MAY, superintendent of motive power of the Lehigh Valley at South Bethlehem, Pa., has been appointed to the same position on the Chicago, Indianapolis & Louisville, with office at La Fayette, Ind., succeeding C. P. Burgman, assigned to other duties. Mr. May began his railroad career with the Chesapeake & Ohio at Covington, Ky., where he served as machinist apprentice from 1892 to 1896. He was then machinist for three years at the same place. In 1899 he became a student in the Mechanical Engineering School of Purdue University at La Fayette, Ind., from which he graduated in 1902. He was then appointed master mechanic on the Cleveland, Cincinnati, Chicago & St. Louis at Louisville, Ky., remaining in that position until 1907. From 1907 to 1910 he served on the Louisville & Nashville as master mechanic at New Decatur, Ala., and at South Louisville, Ky., and from 1910 to about January, 1916, when he went to the Lehigh Valley, he was superintendent of motive power of the Chicago, Indianapolis & Louisville. He now returns to that road to serve in the same capacity.

G. O. HAMMOND, who has been appointed general mechanical superintendent of the New York, New Haven & Hartford with headquarters at New Haven, Conn., as has already been announced in these columns, was born on April 20, 1874, in New York City. He graduated from the New York public schools and from Stevens Institute of Technology, where he received the degree of mechanical engineer. In November, 1898, he began railway work as a special machinist at the Susquehanna shops of the Erie Railroad. He subsequently served as special apprentice until December, 1899; then as draftsman to 1901, and during the following year served as engineering clerk. He was general foreman of the Meadville shops until 1903, and later served as machinery inspector until 1905, and as chief draftsman from January to July, 1905, when he became mechanical engineer. He subsequently served as assistant mechanical superintendent and assistant to general mechanical superintendent until January, 1909, when he became mechanical engineer for the New York Air Brake Company. From February, to April, 1913, he acted as assistant superintendent on the New York, New Haven & Hartford. From May, 1913, to May, 1917, he was assistant mechanical superintendent and then was appointed assistant general mechanical superintendent, which position he held until his recent appointment as general mechanical superintendent.

G. O. Hammond

R. J. WILLIAMS has been appointed superintendent of motive power on the Pere Marquette, with headquarters at Detroit, Mich., succeeding W. L. Kellogg, resigned.

FRANCIS M. WARING, acting engineer of tests of the Pennsylvania Railroad at Altoona, Pa., has been appointed engineer of tests. Mr. Waring was born on September 28, 1879, at Charleston, S. C., and is a graduate of the Charleston High School and Virginia Polytechnic Institute. He began railway work with the Northern Central at Baltimore, Md., on November 14, 1898. On March 5, 1900, he entered the employ of the Pennsylvania Railroad, on special duty at Williamsport, Pa. On November 1, 1901, he was transferred to Baltimore on special duty and subsequently served there as a machinist until July 17, 1902, when he again returned to Williamsport to be assigned to special work. On November 1, 1902, he became a draftsman there, and on October 19, 1903, was made an inspector at Altoona. He entered the test department on September 11, 1912, as foreman of the physical laboratory, and from June 1, 1917, until

he received his recent appointment, he has been acting engineer of tests.

JAMES YOUNG, JR., assistant master mechanic of the Philadelphia, Baltimore & Washington at Wilmington, Del., has been appointed assistant engineer of motive power of the New Jersey division of the Pennsylvania Railroad, with headquarters at New York, succeeding James B. Diven. Mr. Young was born on May 25, 1885, and graduated from Purdue University in 1907. His first railroad work was performed as an apprentice in the summer of 1902. On June 19, 1907, following his graduation, he became a special apprentice in the Altoona, Pa., shops. He was advanced to inspector in the Altoona machine shop on June 27, 1909, to assistant storekeeper on November 15 of the same year, and on December 16, 1909, was appointed inspector on the New Jersey division. He was made assistant engine house foreman at West Morrisville, Pa., on November 1, 1910, and from February 5, 1917, to September 1, 1917, when he received his latest appointment, he was assistant master mechanic at Wilmington, Del.

W. H. SAMPLE, master mechanic of the Grand Trunk at Montreal, Que., has been appointed superintendent of motive power, with headquarters at Montreal, Quebec. Mr. Sample was born in 1864, at Altona, N. Y., and was educated at the high school of his native town. He began railway work in 1882, as fireman on the Central Vermont, and in 1886 was promoted to engineman. From 1887 to 1890, he served on the Santa Fe System as engineman, and then returned to the Central Vermont. In 1901 he was appointed road foreman of engines, remaining in that position until 1906. He then entered the service of the United Fruit Company as superintendent of motive power and car departments on the Northern Central Railway of Costa Rica, Central America, resigning from that position in 1911 to go to the Grand Trunk as master mechanic on the Ottawa division. He was transferred as master mechanic to the western lines in 1914, and in 1916 was again transferred in the same capacity to the eastern lines.

W. H. Sample

MASTER MECHANICS AND ROAD FOREMEN OF ENGINES

C. W. BURKET has been appointed assistant master mechanic of the Monongahela division of the Pennsylvania Railroad with office at South Pittsburgh, Pa., succeeding E. H. Newbury.

A. W. BYRON, master mechanic of the New York, Philadelphia & Norfolk at Cape Charles, Va., has been furloughed from railroad service to enter the Officers' Training Camp at Fort Oglethorpe, Ga.

A. MCDONALD, foreman of the erecting shop of the Grand Trunk at Stratford, Ont., has been appointed assistant master mechanic, with headquarters at the Montreal shops.

B. H. DAVIS, assistant master mechanic of the Delaware, Lackawanna & Western at Scranton, Pa., has been appointed master mechanic of the Scranton, Syracuse & Utica and Bangor & Portland divisions, with jurisdiction over engine houses and matters pertaining to road work; succeeding F. H. Reagan, resigned to accept service elsewhere.

CHARLES W. MCGUIRK, general foreman in the motive power department of the Delaware, Lackawanna & Western at Scranton, Pa., has been appointed assistant master mechanic at Scranton, succeeding B. H. Davis.

E. R. BATTLEY, general foreman of the Grand Trunk at Deering, Me., has been appointed master mechanic of the Eastern lines, with office at Montreal, Que. Mr. Battley was originally employed by the Grand Trunk as a machinist apprentice at Stratford, Ont., from December 1, 1902, to December 1, 1907, when he became a machinist. He served in this capacity until January, 1909, when he was advanced to the position of shop inspector at Stratford. On March 12, 1910, he was appointed locomotive foreman at Fort Erie, Ont., which position he held till July 1, 1914. He then was transferred to Deering, Me., where he served as general foreman until he was promoted to his present position in September, 1917.

E. R. Battley

W. J. MCLEAN, for the past five years master mechanic of the Kettle Valley at Penticton, B. C., has resigned.

CHARLES J. HALLIWELL, inspector in the office of the general superintendent of motive power of the Pennsylvania Railroad at Altoona, Pa., has been appointed master mechanic in charge of the company's shops at Mt. Carbon, Pa., succeeding J. H. Fulmor. Mr. Halliwell was born at Altoona, Pa., on March 29, 1874. He entered the service of the Pennsylvania Railroad as a laborer in the Altoona shops on July 3, 1889. Two years later he became an apprentice, and on April 22, 1895, he was promoted to machinist. On October 1, 1899, he became gang leader at Altoona, and in March of the following year was advanced to foreman on the Pittsburgh division. Mr. Halliwell was made assistant master mechanic of the Pittsburgh division on March 1, 1906, and on December 1, 1912, returned to Altoona as inspector in the office of the general superintendent of motive power, acting in that capacity until September 1, 1917, when he received his appointment as master mechanic at Mt. Carbon, Pa.

C. J. Halliwell

JAMES B. DIVEN, assistant engineer of motive power of the New Jersey division of the Pennsylvania Railroad, at New York, has been appointed master mechanic of the Philadelphia Terminal division, with office at West Philadelphia,

Pa., succeeding P. L. Grove. Mr. Diven was born on October 21, 1878, at Landisburg, Pa., and graduated from the Williamson School in 1898. He began his railroad service on April 18, 1898, as an apprentice at the Altoona shops. He was made machinist on May 15 of the following year, and on April 1, 1900, was appointed inspector in the office of the assistant engineer of motive power at Altoona. On August 1 of the same year he was made draftsman in the office of the superintendent of motive power at Buffalo, and on November 1 was appointed inspector. On January 15, 1902, Mr. Diven was advanced to the position of assistant master mechanic at Verona, N. Y. He was promoted to master mechanic of the Cumberland Valley Railroad on September 30, 1904, and from April 1, 1907, until he received his recent appointment, he was assistant engineer of motive power of the New Jersey division.

Franklin E. Marsh, assistant master mechanic of the Altoona machine shop of the Pennsylvania Railroad, has been appointed master mechanic of the New York, Philadelphia & Norfolk, with headquarters at Cape Charles, Va., succeeding A. W. Byron. Mr. Marsh was born on November 20, 1876, at Newark, N. J. He attended the public schools of that city and completed his education in the Newark Technical School. He was first employed in railroad service on January 25, 1897, as a special apprentice on the Pennsylvania Railroad, becoming a machinist on May 1, 1901, and inspector in the Altoona machine shop on July 1 of the same year. On July 12, 1902, Mr. Marsh was transferred to the Wilmington, Del., shop, as inspector, and was made assistant road foreman of engines of the Maryland division on June 8, 1903. He was advanced to assistant master mechanic at Trenton, N. J., on December 10, 1906, and was appointed assistant master mechanic of the Altoona machine shop on September 26, 1910, which position he held when he received his recent appointment.

E. S. McMillan has been appointed road foreman of engines of the Grand Trunk, Montreal terminals, succeeding F. H. Holland, assigned to other duties.

Victor U. Powell, master mechanic of the Illinois Central at Freeport, Ill., has been transferred to the Chicago Terminal and Illinois division, with office at Burnside shops, Chicago, succeeding Henry C. Eich.

A. B. Ogilvie has been appointed road foreman of engines of the Grand Trunk, with jurisdiction over the thirty-first and thirty-second districts, including the Ottawa terminal, succeeding W. M. Cooper, assigned to other duties.

G. M. Wilson, assistant master mechanic of the Grand Trunk at Montreal, Que., has been promoted to master mechanic, with headquarters at the same place, succeeding A. A. Mayer, retired. Mr. Wilson was born in Belfast, Ireland, in 1867. After serving a machinist apprenticeship he entered the employ of the Grand Trunk in November, 1890, as machinist, at Fort Gratiot, Mich., and subsequently filled the positions of machine shop foreman, general foreman of the Toronto shops, general inspector of tests and assistant master mechanic. In 1907 he had charge of the layout, and supervised the installation of the entire machinery equipment of the main shops of the Western division, at Battle Creek, Mich., and on the completion of this work was located at Ottawa, Ont., supervising the installation of the power house in connection with the new station and the Chateau Laurier.

SHOP AND ENGINEHOUSE

A. C. Adams, master mechanic of the Seaboard Air Line at Raleigh, N. C., has resigned that position to become superintendent of shops of the New York, New Haven & Hartford at Readville, Mass. Mr. Adams was educated in the common schools and served a machinist apprenticeship on the Missouri Pacific. He went to the Chicago, Rock Island & Pacific as a machinist in 1887 and was promoted to master mechanic on the Colorado division in 1900, later being transferred to the Oklahoma and Missouri divisions. In 1906, he accepted a position as master mechanic on the Alliance division of the Chicago, Burlington & Quincy and in November, 1907, went to the Delaware, Lackawanna & Western as master mechanic at Hoboken, N. J. In November, 1908, he entered the service of the New York, New Haven & Hartford, acting in the same capacity on the Shore Line division. He resigned that position in February, 1911, to become superintendent of motive power of the Spokane, Portland & Seattle and the Oregon Electric & United Railways at Portland, Ore. In February, 1914, he went into the supply business, but again entered railroad service, becoming master mechanic of the Seaboard Air line, which position he held until recently.

J. C. Breckenfeld, inspector of tools and machinery of the New York, New Haven & Hartford, has been appointed assistant superintendent of locomotive shops, with headquarters at Readville, Mass.

H. W. Brewer, formerly erecting shop foreman at the West Albany shops of the New York Central, has resigned to become general foreman of the Du Bois (Pa.) shops of the Buffalo, Rochester & Pittsburgh.

Joseph Greiser, general foreman in the motive power department of the Delaware, Lackawanna & Western at Scranton, Pa., has been appointed superintendent of shops, with jurisdiction over the Scranton locomotive shops.

John Reid, general foreman of shops of the New York, New Haven & Hartford at New Haven, Conn., has been promoted to the position of inspector of tools and machinery, suceeding J. C. Breckenfeld.

E. V. Williams, formerly general foreman of the New York Central at the West Albany shops, has resigned to accept the position of superintendent of shops of the Buffalo, Rochester & Pittsburgh, with headquarters at Du Bois, Pa.

CAR DEPARTMENT

T. A. Heminway, car repair foreman of the Delaware & Hudson at Colonie, N. Y., has been appointed divisional car foreman of the Saratoga division, with headquarters at Colonie.

J. E. O'Neil, car repair foreman of the Delaware & Hudson at Oneonta, N. Y., has been appointed divisional car foreman of the Susquehanna division, with headquarters at Oneonta.

PURCHASING AND STOREKEEPING

J. A. Brackett, division storekeeper of the Atchison, Topeka & Santa Fe at Barstow, Cal., has been transferred to Calwa, Cal., succeeding O. H. Hansen, resigned to enter military service.

John E. Byron has been appointed general storekeeper of the Boston & Maine, with office at Boston, Mass.

C. N. Davids has been appointed purchasing agent of the Denver & Salt Lake, with headquarters at Denver, Colo., succeeding A. A. Dawley, assigned to other duties.

J. L. Diessl has been appointed division storekeeper of the Atchison, Topeka & Santa Fe at Riverbank, Cal., succeeding H. R. Spann.

T. S. Edgell has been appointed division storekeeper of the Mobile & Ohio, with office at Tuscaloosa, Ala., succeeding W. O. Jamison, resigned.

Bayliss McCain has been appointed division storekeeper of the Atchison, Topeka & Santa Fe at Barstow, Cal., succeeding J. A. Brackett.

G. O. HIXON, division storekeeper of the Atchison, Topeka & Santa Fe at Gallup, N. Mex., has been transferred to Winslow, Ariz., succeeding E. J. Burns, assigned to other duties.

F. B. MACSWAIN, storeman on the Canadian Pacific at Ogden, Alta., has been appointed storekeeper, with headquarters at Calgary, succeeding G. F. Rosengren, transferred to Lethbridge.

T. W. MADDEN, storekeeper of the Canadian Pacific, at Revelstoke, B. C., has been transferred to Coquitlam.

H. SHOEMAKER, district storekeeper of the Baltimore & Ohio at Cincinnati, Ohio, will in future have jurisdiction over the Northwest district and Chicago terminals.

H. R. SPANN, division storekeeper of the Atchison, Topeka & Santa Fe at Riverbank, Cal., has been transferred to Gallup, N. Mex., succeeding G. O. Hixon.

W. E. STEEN, storekeeper of the Baltimore & Ohio at Washington, Ind., has been appointed district storekeeper, with jurisdiction over the Southwest district.

N. C. STIBBS, storekeeper of the Canadian Pacific at Lethbridge, Alta., has been transferred to Nelson, B. C., succeeding D. S. Schofield, transferred to Revelstoke, B. C.

G. H. Walters, engineer of tests in the stores department of the Chicago, Milwaukee & St. Paul, at Milwaukee, Wis., has been appointed assistant purchasing agent, with office at Chicago, succeeding A. J. Jennings, resigned.

OBITUARY

C. S. WOOD, for 21 years general foreman of the Boston & Maine roundhouse at Concord, N. H., died on September 12, at the age of 54. Mr. Wood entered the service of the Boston & Maine in 1881 as locomotive fireman, became an engineman in 1885, and general foreman in 1896.

J. F. ENRIGHT, superintendent of the motive power and car departments of the Denver & Rio Grande, died at his home in Denver, Colo., on September 4, after an illness of about one year. He was born at Savannah, Ga., in 1867, and entered railway service in 1885 as a machinist apprentice of the Savannah, Florida & Western, now a part of the Atlantic Coast Line, and remained in the Savannah (Ga.) shops of that road until 1895, when he was appointed general foreman of the shops at Montgomery, Ala. He was subsequently general foreman of shops of the same road at Waycross, Ga., and later master mechanic at Montgomery, Ala. From January, 1902, to January, 1907, he was master mechanic on the Mobile & Ohio at Whistler, Ala., and from the latter date to December, 1909, was superintendent of machinery of the International & Great Northern at Palestine, Texas. From the time he left the I. & G. N. up to the time of his death he was superintendent of the motive power and car departments of the Denver & Rio Grande, with headquarters at Denver, Colo., and during a portion of that period had jurisdiction also over the mechanical department of the Western Pacific.

J. F. Enright

SUPPLY TRADE NOTES

Russell Dale, general sales manager of the Rich Tool Company and manager of the Tungsten Valve Company, Chicago, died in that city on September 22.

E. Kennedy, formerly assistant general foreman at the West Albany shops of the New York Central, is now connected with Manning, Maxwell & Moore, with headquarters at Chicago.

George E. Scott, vice-president of the American Steel Foundries, has become associated with the work of the Red Cross at Washington on the staff of the business manager, H. D. Gibson.

The Acar Manufacturing Company, 30 Church street, New York, has opened a Chicago office, in charge of Leland T. Johnson at room 649, McCormick building. Mr. Johnson will handle matters for this company in the western territory.

The Macleod Company, Cincinnati, Ohio, manufacturers of sand blast equipment and metallurgical furnaces, has found it necessary to enlarge its plant in order to take care of its rapidly expanding business and has increased its capital to $100,000.

Edward F. Carry, president of the Haskell & Barker Car Company, Chicago, has been appointed director of the government shipping board with headquarters at Washington, D. C. Mr. Carry will not sever his connection with the Haskell & Barker Car Company.

Arthur C. Sullivan, formerly with the Hensley Trolley Manufacturing Company, of Detroit, Mich., has been appointed a sales representative of the National Railway Appliance Company, New York. Mr. Sullivan will be attached to the Chicago office of the company.

The Robinson Paint Company, Aurora, Ill., announces that it has purchased the plant, business and good will of the Akron Mining, Milling & Manufacturing Company. The business will be continued along the same general lines as heretofore, with the same organization.

Harry L. Allen, assistant fourth vice-president of the American Steel Foundries, died at Cleveland, Ohio, on August 31, at the age of 35 years. Mr. Allen had been with the company 15 years, coming to it at the time of its organization, from the American Steel Castings Company.

John E. Woods, formerly manager of sales of the Carnegie Steel Company, the Illinois Steel Company and the Tennessee Coal, Iron & Railroad Company, at Cincinnati, Ohio, has been appointed assistant general manager of sales, with offices in the Carnegie building, Pittsburgh, Pa. Mr. Woods succeeds John W. Dix, deceased.

Horace M. Wigney, formerly superintendent of transportation of the Pacific Fruit Express Company, and recently president and general manager of the Dairy Shippers' Despatch Company and the Federal Refrigerator Despatch, has entered the railway supply and equipment business in his own name, with offices at 750 Railway Exchange building, Chicago.

The McCarthy Drill & Tool Corporation of Toledo, Ohio, with executive offices at 30 Church street, New York, has purchased the Toledo Drill & Tool Company, of Toledo, which has just moved into a new and enlarged fireproof two-story structure, where it has arranged to turn out large quantities of high-speed drills, in addition to a full line of cutters and reamers.

George A. Turville, secretary and treasurer of the Crucible Steel Company, has also been elected a vice-president. J. M. McComb, credit manager, has been made assistant treasurer.

The Crane Packing Company of Chicago, manufacturers of "John Crane" flexible metallic packing for all vapors and liquids, announces the establishment of an Eastern office in the Woolworth building, New York. Their engineer, A. W. Payne, who has had much experience with packing problems in the oil, mining and industrial fields, has been placed in charge of this branch.

The United States District Court for the Western District of New York has handed down its decision that the Gould "Simplex" system of electric car lighting is not an infringement of the Creveling patent, 747,686, owned by the Safety Car Heating & Lighting Company, and has directed that the suit be dismissed with costs to the Gould Coupler Company. This disposes of the last charge that the Gould "Simplex" system infringes any patent.

E. N. Sanctuary, president of the Oxy-Acetylene Appliance Company, of New York, formerly engineer and secretary of the Bowers Southern Dredging Company, of Galveston, Tex., and an experienced construction engineer, has been commissioned a captain in the Engineer Officers' Reserve Corps, and has been assigned to the Washington office of S. M. Felton, director general of railways, in charge of the personnel of railway troops organized for service abroad.

The Titanium Alloy Manufacturing Company announces that the constantly increasing demand for superior bronze and brass castings has compelled it to enlarge its bronze department and make a distinct unit of it under the name of the Titanium Bronze Company, Inc. The company's works are at Niagara Falls, N. Y.; its sales offices at Buffalo, and its general offices at 165 Broadway, New York.

The Bradford-Ackermann Corporation, Forty-second street building, New York City, has been made the eastern sales office for the Young Brothers Company, Detroit, Mich. The sale of Young ovens, for japanning and drying purposes, will in the future be handled by this eastern office for the New England states, New York, New Jersey, Maryland, Delaware and eastern Pennsylvania. An engineering department will likewise be available for manufacturers in the East who are interested in quick drying and baking processes, and special oven designs will be offered to meet various requirements.

W. G. Dunham, since 1907 in charge of the manufacture of McCord & Co., products in Canada, with headquarters at Brantford, Ont., died September 8 at the age of 62 years. Mr. Dunham was born in Canada, and came to this country as a young man. In 1884 he entered the employ of the Chicago, Burlington & Quincy, and was with that road as foreman of the old Sixteenth street passenger yards of that company in Chicago during the Debs strike in 1894, when he succeeded in keeping his department operating without damage to railroad property. He entered the employ of McCord & Co. in 1902, and prior to going to Brantford was mechanical inspector.

H. McB. Parker, sales representative of the Hunt-Spiller Manufacturing Corporation, Boston, Mass., who entered the Officers' Training Camp at Plattsburg in May, and was thereafter detailed to special duty in the Submarine Signal Company, has enlisted in the United States Navy, and has been assigned to one of the United States destroyers, which has sailed for France. C. L. Galloway has been appointed sales representative of the Hunt-Spiller Manufacturing Corporation for the Northeastern district. Mr. Galloway for the last 18 years has been in the employ of the New York, New Haven & Hartford, in and about Boston, and serving in various capacities in the mechanical department.

Thomas H. Garland, president of the Garland Ventilator Company, Chicago, whose death was announced in the *Railway Mechanical Engineer*, last month, was born at Augusta, Me., on December 10, 1855. He entered railway service as a brakeman with the Chicago, Burlington & Quincy, at Quincy, Ill., in 1872, and several years later became baggage man at the same point. In 1882 he was promoted to clerk in the freight office at Chicago, and later was appointed chief clerk in the same department, which position he held until his appointment as superintendent of refrigerator car service. In 1908 he left the Burlington to engage in the railway supply business in which he was interested until his death.

Frank W. Davis, manager of railroad sales of the Lake Erie Iron Company, Cleveland, Ohio, died very suddenly of heart disease at the Royal Muskoka hotel, Muskoka, Canada, August 8. Mr. Davis was born in Cleveland, January 1, 1857. He received his education in the Cleveland public schools and Oberlin College and commenced his business career with Bingham & Phelps, who at that time conducted a retail hardware business on Ontario street. He afterward engaged as a commercial traveler, and while on one of his trips he became acquainted with C. W. Scofield, secretary and treasurer of the Lake Erie Iron Company, who eventually employed him as a salesman for that company. He remained in the service of the Lake Erie Iron Company, for 27 years.

Automatic Straight Air Brake Company

The Automatic Straight Air Brake Company has been incorporated under the laws of Delaware with a capital stock of $5,000,000 preferred and $20,000,000 common to manufacture and sell a new type of air brake, the invention of Spencer G. Neal, who is the designing engineer of the company.

The directors are A. B. Boardman, A. M. McCrea, K. B. Conger, H. I. Miller, C. R. Ganter, S. C. Holaday, A. M. Trueb and G. C. Pierce.

The officers will be H. I. Miller, chairman of the board and president; K. B. Conger, vice-president and treasurer; A. M. Trueb, secretary and auditor, and G. C. Pierce, chief engineer. The office of the company is at 14 Wall street, New York.

A railroad officers' demonstration of the brake will take place in New York during the early part of October, and arrangements for manufacture are well under way. The company will not build its own plant until after the war.

Baldwin Locomotive Works

President Alba B. Johnson of the Baldwin Locomotive Works announces the following changes in the organization of that company and of the Standard Steel Works Company. In the Baldwin Locomotive Works no change has been made with respect to William L. Austin, chairman of the board, or Alba B. Johnson, president. Samuel L. Vauclain, hitherto vice-president, however, becomes senior vice-president; Grafton Greenough, sales manager, now becomes vice-president in charge of sales; J. P. Sykes, general superintendent, becomes vice-president in charge of manufacture, and James McNaughton, formerly vice-president of the American Locomotive Company, becomes consulting vice-president.

In the Standard Steel Works Company, William Burnham, heretofore president, has been elected chairman of the board, and other officers have been elected as follows: Alba B. Johnson, president; Samuel M. Vauclain, senior vice-president; Robert Radford, vice-president and treasurer; A. A. Stevenson, vice-president and engineer; Wm. H. Pugh, Jr., secretary; T. L. Rogers, assistant treasurer, and O. C. Skinner, works manager.